Appendix J

Historical and Future Reservoir Operating Conditions on the Lower Colorado River

Contents

Page

Tables

Figures

On Page

Acronyms and Abbreviations

af	acre-feet
afy	acre-feet per year
AGC	Automatic Generation Control
BA	Biological Assessment
BIA	Bureau of Indian Affairs
BO	Biological Opinion
BWC	Basic Water Company
CAP	Central Arizona Project
CBRFC	Colorado Basin River Forecast Center
CESA	California Endangered Species Act
cfs	cubic feet per second
Corps	U.S. Army Corps of Engineers
CRSS	Colorado River Simulation System
ESA	federal Endangered Species Act
ISG	Interim Surplus Guidelines
kaf	thousand acre-feet
kW	kilowatts
LCR	Lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
LROC	Long Range Operating Criteria
maf	million acre-feet
mafy	million acre-feet per year
1944 Water Treaty	*Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande—Treaty between the United States of America and Mexico*, dated February 3, 1944
msl	mean sea level
Metropolitan	Metropolitan Water District of Southern California
NIB	Northerly International Boundary
NPS	National Park Service
PVID	Palo Verde Irrigation District
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Secretary	Secretary of the Interior
SIB	Southerly International Boundary with Mexico
SNWA	Southern Nevada Water Authority
USFWS	U.S. Fish & Wildlife Service
Western	Western Area Power Administration
YAO	Yuma Area Office
YDP	Yuma Desalination Plant

Appendix J

Technical Documentation of Ongoing and Future Operations

J.1 Introduction

This appendix to the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) is intended to supplement the information provided therein, including the Federal actions specified in Chapter 2 of the LCR MSCP Biological Assessment (BA). Specifically, this appendix presents an overview of current lower Colorado River (LCR) operations, a summary of historical operating conditions, and an evaluation of the hydrologic impacts of future flow-related actions described in Chapters 2 of the LCR MSCP BA and Habitat Conservation Plan (HCP).

The content and organization of this appendix is as follows:

- J.1, “Introduction,”
- J.2, “Relationship of this Appendix to the LCR MSCP BA and HCP,”
- J.3, “Geographic Scope,”
- J.4, “Overview of Operations on the LCR,”
- J.5, “Historical LCR Operating Conditions,”
- J.6, “Evaluation of the Hydrologic Impacts of Future Flow-Related Actions,”
- Attachment A, “Detailed Modeling Documentation,”
- Attachment B, “Sensitivity Analysis: Evaluation of the Incremental Effects of Flow-related Actions Being Considered Under the LCR MSCP (Specific Surplus and Shortage Strategies and Changes in the Points of Delivery of State Entitlement Waters),”
- Attachment C, “Initial Reservoir Conditions,”
- Attachment D, “Analysis of Hydrology Impacts to River Corridor (Reaches 3–5),” and
- Attachment E, “Evaluation of Effects Associated with Updated Hydrologic Information.”

J.2 Relationship of this Appendix to the LCR MSCP BA and HCP

The LCR MSCP BA and Habitat Conservation Plan (HCP) evaluated and identified the likely effects on threatened and endangered species and their habitat from Lake Mead to the Southerly International Boundary with Mexico (SIB) resulting from the implementation of the covered actions and activities described in Chapters 2 of the LCR MSCP BA and HCP. The discussion of historical operating conditions and current LCR operations in this appendix provide additional explanation of the ongoing Federal flow-related actions described in Chapter 2 of the LCR MSCP BA. The information in this appendix provides the hydrologic portion of the impact analyses presented in Chapter 5 of the LCR MSCP BA and in Chapter 4 of the LCR MSCP HCP.

J.3 Geographic Scope

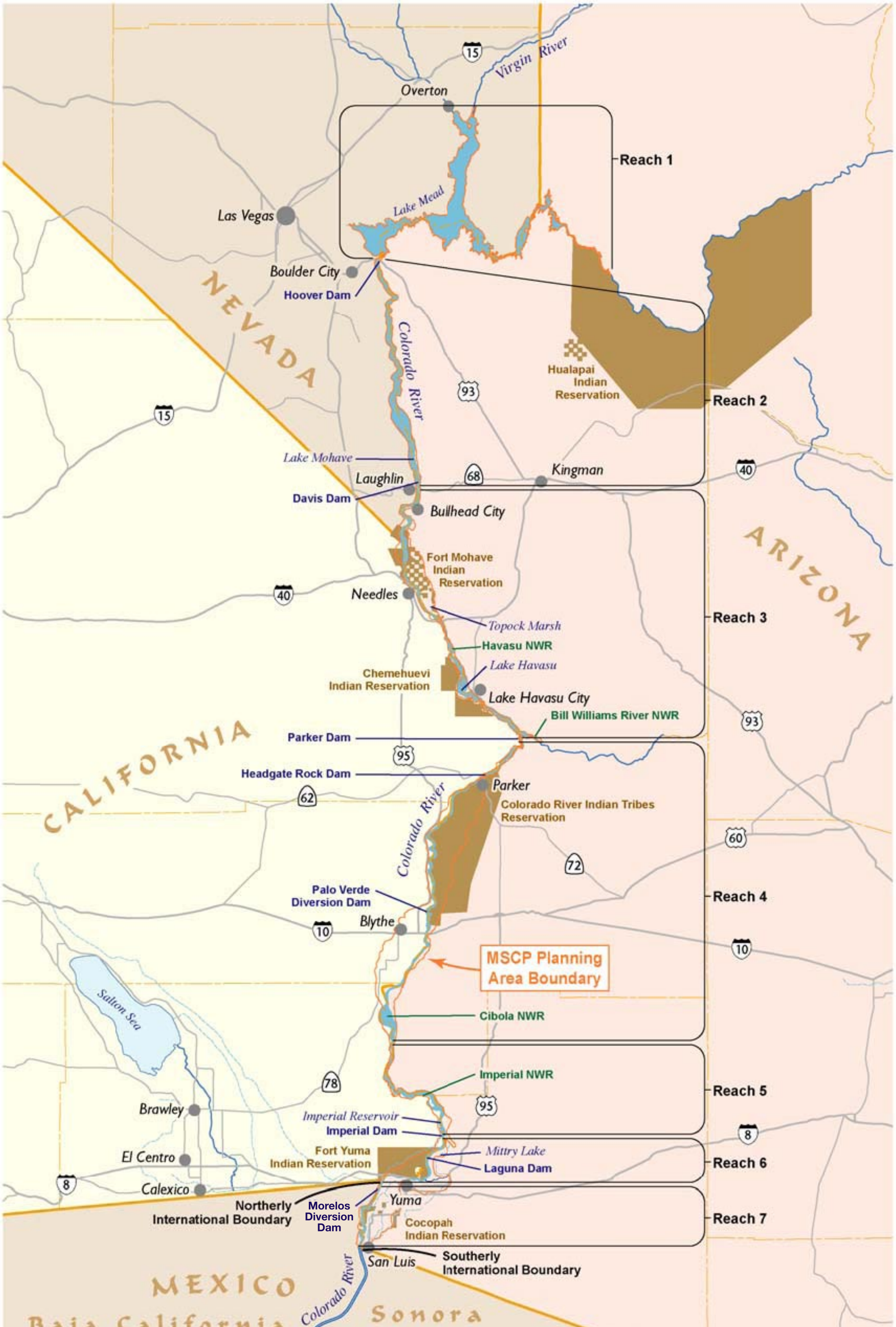
The LCR MSCP planning area comprises areas up to and including the full-pool elevations of Lakes Mead, Mohave, and Havasu, and the historic floodplain of the Colorado River from Lake Mead to the SIB. This area was divided into reaches as shown in Figure J-1. This appendix evaluates the hydrologic impacts of future flow-related actions in Reaches 1 (Lake Mead) and Reaches 3–5 (Davis Dam to Imperial Dam). Hydrologic impacts of future flow-related actions in Reach 7 are presented in Appendix L. The hydrologic impacts of the future flow-related actions in Reach 2 (Hoover Dam to Davis Dam) were determined to be insignificant since that reach is dominated by backwater from Lake Mohave. Similarly, the hydrologic impacts of the future flow-related actions in Reach 6 (Imperial Dam to Morelos Diversion Dam) were determined to be insignificant since that reach is dominated by drainage return flows, not releases from upstream reservoirs that would be affected by the future flow-related actions; moreover, the anticipated future changes in points of diversion would occur upstream of Imperial Dam, as described in Chapter 2 of the LCR MSCP BA.

J.4 Overview of Operations on the LCR

This section provides an overview of operations on the LCR from Lake Mead to SIB. Specifically, the operations of Lakes Mead, Mohave, and Havasu, as well as operations in the Yuma Area are outlined under flood control and non-flood control operating conditions. Both mid-range (governed by the Annual Operating Plan) and short-range operations (governed by water and power demands) are discussed.

J.4.1 General

The Colorado River serves as a source of water for irrigation, domestic and other uses in the States of Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming and in Mexico. The Colorado River also serves as a source of water for a variety of



Lower Colorado River Multi-Species Conservation Program

Figure J-1
Lower Colorado River MSCP Planning Area and River Reaches

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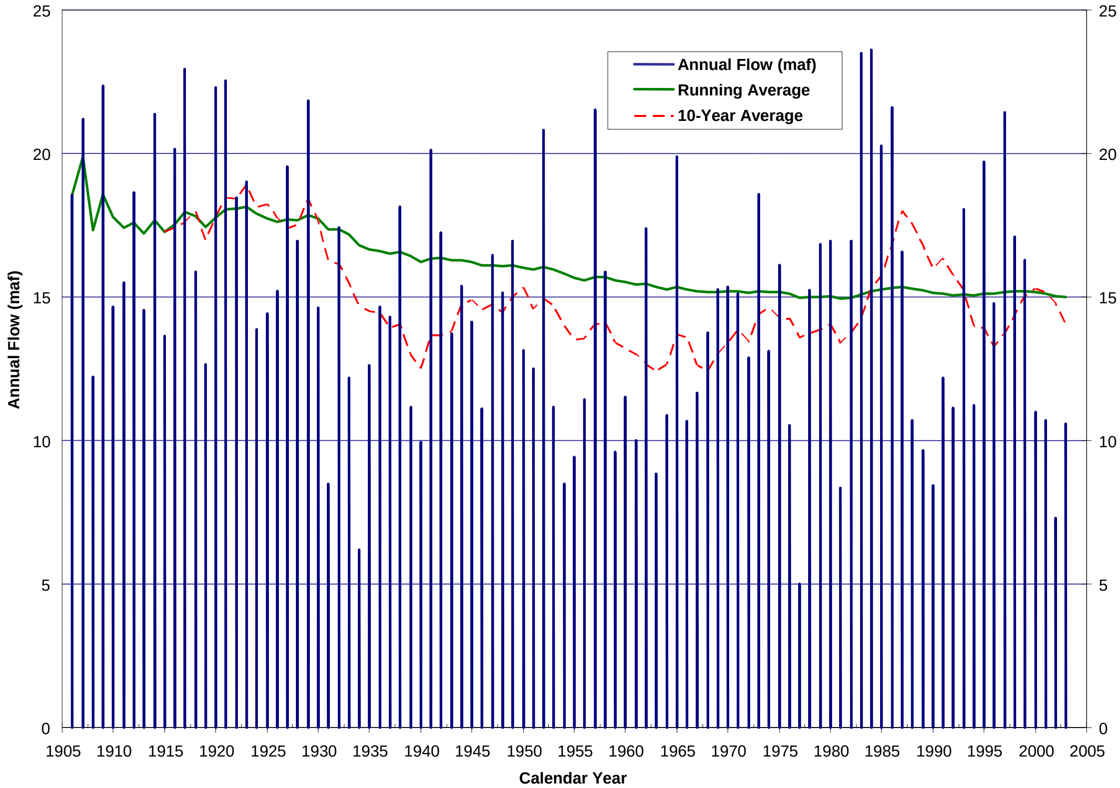
recreational and environmental benefits. The Colorado River Basin is located in the southwestern United States and occupies a total area of approximately 250,000 square miles. The Colorado River is approximately 1,400 miles in length and originates along the Continental Divide in Rocky Mountain National Park in Colorado. Elevations in the Colorado River Basin range from sea level to over 14,000 feet mean sea level (msl) in the mountainous headwaters.

Climate varies significantly throughout the Colorado River Basin. Most of the Colorado River Basin is comprised of desert or semi-arid rangelands, which generally receive less than 10 inches of precipitation per year. In contrast, many of the mountainous areas that rim the northern portion of the Colorado River Basin receive, on average, over 40 inches of precipitation per year. Most of the total annual flow in the Colorado River Basin results from natural runoff from mountain snowmelt. Because of this, natural flow is very high in the late spring and early summer, diminishing rapidly by mid-summer. While flows in late summer through autumn sometimes increase following rain events, natural flow in the late summer through winter is generally low. Major tributaries to the Colorado River include the Green, San Juan, Yampa, Gunnison and Gila Rivers.

The annual flow of the Colorado River varies considerably from year to year. The natural flow at the Lees Ferry gaging station (see Figure J-2), located 17 river miles below Glen Canyon Dam, has varied annually, from a minimum of 5.4 million acre-feet (maf) to a maximum of 25.4 maf. Natural flow represents an estimate of flows that would exist without upstream reservoir regulation, depletions, or transbasin diversions. Most of the water in the lower portion of the Colorado River flows into the Lower Basin from the Upper Basin and is accounted for at Lees Ferry, Arizona. In years when the minimum objective release is being made from Glen Canyon Dam, about 86 percent of the annual natural supply in the Lower Basin is attributed to the releases from the Upper Basin. The remaining 14 percent of the water in the lower portion of the river is attributed to sidewash inflows due to rainstorms and tributary rivers in the Lower Basin. In this area, the Colorado River's mean annual tributary inflow is approximately 1.35 maf, excluding the intermittent Gila River inflow. Actual Lower Basin tributary inflows are highly variable from year to year.

Annually, approximately 9 maf are released from Lake Mead to meet the delivery orders of water entitlement holders in the U.S. and for 1944 Water Treaty deliveries to Mexico. Of this amount, some 7.5 maf are entitlements for the Lower Basin States (Nevada, Arizona, and California), while the remaining 1.5 maf is delivered to Mexico. The 1944 Water Treaty is the *Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande—Treaty between the United States of America and Mexico*, dated February 3, 1944.

Figure J-2
Historical Natural Flows at Lees Ferry Stream Gage



Note: 1996–2003 data is Provisional Data and is subject to change.

As previously noted, the focus of this appendix is on the LCR and the operation of the major storage facilities (reservoirs) on the main stem of the LCR. The major reservoirs are presented in Table J-1.

Table J-1. Major Storage Facilities on the Main Stem of the Lower Colorado River

Reservoir	Dam
Lake Mead	Hoover Dam
Lake Mohave	Davis Dam
Lake Havasu	Parker Dam

The locations of these listed storage facilities are illustrated on Figure J-1. Other smaller reservoirs within the Yuma Area of the LCR include: Senator Wash Reservoir, Imperial Reservoir, and Laguna Reservoir.

Individual dams serve one or more specific purposes as designated in their federal construction authorizations. Such purposes include: water storage, flood control, river regulation, power generation, and water diversion to Arizona, California, Nevada and delivery to Mexico. Background information on each major storage facility is provided below.

J.4.1.1 Hoover Dam and Lake Mead

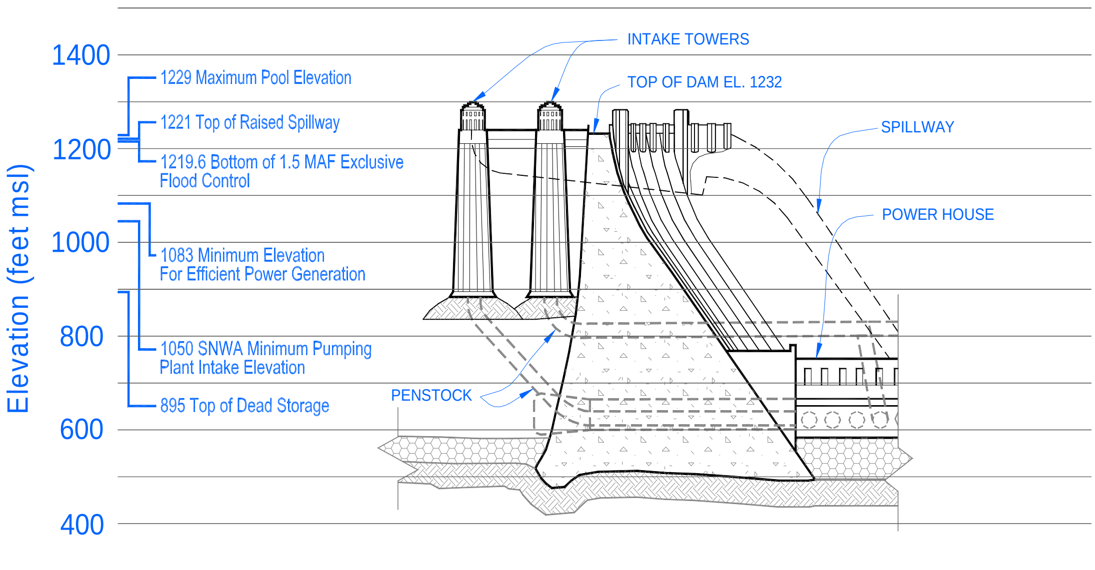
Hoover Dam was constructed in the Black Canyon of the Colorado River about 36 miles from Las Vegas, Nevada. Hoover Dam was constructed to provide storage for river regulation and flood control, storage of water for irrigation and domestic uses, and generation of hydropower. The dam is 726 feet msl high and the water depth is approximately 590 feet msl. Lake Mead can store water to a maximum elevation of 1,229 feet msl (maximum water surface). The tops of the Hoover Dam spillway gates, in the raised position, are at an elevation of 1,221 feet msl. At that water surface elevation, Lake Mead has a nominal “live capacity” of 27.377 maf and an active capacity of 17.353 maf above elevation 1,083 feet msl, the generally accepted minimum elevation for efficient power generation. The dam backs water upstream approximately 115 miles, creating a surface area of about 163,000 acres at its maximum design water surface elevation of 1,229 feet msl. The designated exclusive flood control space of 1.5 maf is situated between elevation 1,219.6 feet msl and 1,229 feet msl.

The Hoover Dam Power Plant is a major source of hydropower in the Southwest. The dam’s four intake towers draw water from the reservoir to drive 17 generators located within the power plant. The power plant generating capacity is rated at approximately 2,074 megawatts (MW) at a maximum release capacity of approximately 49,000 cubic feet per second (cfs). The uncontrolled spillways have a maximum release capacity of about 400,000 cfs. The power is marketed by the Western Area Power Administration (Western).

The Boulder Canyon Project Act of 1928 specified the following priorities for the operation of Hoover Dam and Lake Mead: 1) provide for river regulation, improvement of navigation, and flood control, 2) the delivery of irrigation and domestic water supplies, including the satisfaction of present perfected water rights, and 3) maximize power generation.

Flood control operating criteria for Lake Mead was established to manage potential flood events arising from rain and snowmelt. As previously noted, Lake Mead’s uppermost 1.5 maf of storage capacity, between elevations 1,219.6 feet msl and 1,229.0 feet msl, is defined as exclusive flood control. Within this capacity allocation, 1.218 maf of flood storage is above elevation 1,221 feet msl, the top of the raised spillway gates. Figure J-3 illustrates some of the important Hoover Dam and Lake Mead water surface elevations that are referenced in subsequent sections.

Figure J-3
Lake Mead and Hoover Dam Important Operating Elevations



Lake Mead usually is at its maximum water level in November and December. If required, system storage space-building is achieved between August 1 to January 1. Hoover Dam storage space-building releases are limited to 28,000 cfs, while the mean daily releases to meet the water delivery orders of Colorado River water entitlement holders normally range between 5,000 cfs to 20,000 cfs.

In addition to controlled releases from Lake Mead to meet water supply requirements, water is also diverted from Lake Mead at the Southern Nevada Water Authority (SNWA) Saddle Island intake facilities, Boulder City's Hoover Dam intake, and the Basic Water Company's (BWC) intake facility for use in the Las Vegas area for domestic purposes by SNWA, BWC and other users.

The diversions by SNWA at its Saddle Island intake facilities entail pumping the water from the intake to SNWA's transmission facilities for treatment and further conveyance to the Las Vegas area. The elevation of the original SNWA intake is approximately 1000 feet msl. However, the minimum required Lake Mead water level necessary to operate the pumping units at SNWA's original intake facility is 1,050 feet msl. SNWA recently constructed a second intake at an elevation of 950 feet msl. The minimum required Lake Mead water level necessary to operate the pumping units at SNWA's second intake facility is approximately 1,000 feet msl.

J.4.1.2 Davis Dam and Lake Mohave

Davis Dam and Davis Power Plant are located 67 miles downstream from Hoover Dam, and approximately two miles upstream from Laughlin, Nevada, and Bullhead City, Arizona. The reservoir's primary purpose is to re-regulate Hoover Dam releases and aid in the delivery of water supplies to downstream U.S. entitlement holders and to Mexico. Located on the Arizona side of the river, the Davis Dam Power Plant has five generating units, with a generating capacity of 255,000 kilowatts (kW), and with a combined hydraulic capacity of 31,000 cfs. The power is marketed by Western.

Lake Mohave is situated behind Davis Dam and is bounded for most of its 67-mile length by the steep walls of Pyramid, El Dorado, and Black Canyons. The lake is relatively narrow, not more than four miles across at its widest point, but provides significant recreation opportunities and habitat for fish and wildlife. The lake also captures and delays flash flood discharge from the side washes below Hoover Dam. Typical flow time from Hoover Dam to Lake Mohave is four to six hours. The lake has a storage capacity of approximately 1.818 maf.

J.4.1.3 Parker Dam and Lake Havasu

Parker Dam is located approximately 155 miles downstream from Hoover Dam. Lake Havasu, formed by Parker Dam, is about 45 miles long and can store nearly 648,000 acre-feet (af) of water. At its maximum water surface elevation of 450.5 feet msl, the lake has a surface area of approximately 20,390 acres. Lake Havasu provides a forebay and desilting basin from which water is pumped into the Colorado River Aqueduct (California) and the Central Arizona Project (CAP) Aqueduct. The pumping plant that pumps water into the Colorado River Aqueduct is located on the west side of the river and is operated by The Metropolitan Water District of Southern California (Metropolitan). The pumping plant that pumps water into the CAP Aqueduct is located on the east side of the river and is operated by the CAP.

Parker Dam is the deepest dam in the world, in terms of the portion of the dam that is buried below the river bottom. Approximately 73 percent of its structural height of 320 feet msl is situated below the original riverbed. Only about 85 feet msl of the dam's total height is visible.

The Parker Dam Power Plant is located on the California side of the Colorado River immediately below the dam. It houses four hydroelectric generating units. The installed generating capacity is 120,000 kW, but due to high tailrace elevation, the generation production is approximately 108,000 kW. Four 22-foot diameter penstocks carry up to 5,500 cfs each to feed the generating units. About 50 percent of the plant's power output is reserved in perpetuity by Metropolitan for pumping water along the Colorado River Aqueduct to the Southern California Coastal area. The remaining power is marketed by Western.

J.4.1.4 Facilities in the Yuma Area

Reclamation owns and operates various facilities in the Yuma Area that are used in the delivery of water supplies to users on the U.S. side, to Mexico, and in the management and regulation of the Colorado River. These facilities include: dams and water storage reservoirs, diversions and turnout structures, four drainage well fields and related drainage canals, Yuma Desalting Plant and International canal system, and other related facilities. Local water districts also operate and maintain irrigation and drainage facilities for Reclamation under contracts executed with Reclamation.

Imperial Dam is operated primarily as a diversion dam, providing water to the All-American and the Gila Gravity Main Canals to meet the beneficial use requirements of entitlement holders in California and Arizona. Releases may also be made to meet a portion of the 1944 Water Treaty deliveries to Mexico. Occasionally (two to three times per month), water is released through the sluice gates at Imperial Dam to move accumulated sediment to the Laguna Desilting Basin which is located about two miles downstream from Imperial Dam. The Laguna Desilting Basin, located within the Colorado River channel, is used to decant the water that is released or that passes Imperial Dam.

Laguna Dam is operated to regulate river flows and to temporarily store water used in sluicing operations at Imperial Dam. Any water that is captured and temporarily stored at Laguna Reservoir is released to meet a portion of the 1944 Water Treaty deliveries to Mexico.

Senator Wash Reservoir is an off-stream water storage facility that is used to regulate river flows. The reservoir is used to capture any excess flows arriving at Imperial Dam. Additionally, any shortfalls in river flows and supply can be made up by releasing water from Senator Wash Reservoir. Senator Wash Reservoir is situated at a higher elevation than the adjacent Colorado River. As such, any water that is to be stored in the reservoir has to be pumped via the Senator Wash Pumping/Generating Plant. When water is released from Senator Wash Reservoir through the Senator Wash Pumping/Generating Plant, hydroelectric power is generated.

Reclamation also operates, either by itself or jointly with other agencies, various drainage systems that are used to facilitate the drainage of lands within Yuma Valley, Yuma Mesa, and the Wellton-Mohawk area. These drainage systems include several well fields that are used to manage the groundwater in the underlying groundwater basins. Drainage water that is pumped from these drainage wells or that is collected in the open drains, is pumped and conveyed to the Colorado River via different conveyance facilities.

Additional information on these facilities and their operation is provided in Section J.4.3.2.

J.4.1.5 Coordination of Water and Power Operations

As noted in Section J.4.1.1, power generation is the third priority with respect to river operations, as stated in project-specific legislation, and as referred to under the Law of the River. Reclamation is the Federal agency that manages the generation of hydro-electric power at the Hoover, Davis, and Parker Power Plants. Western is the Federal agency that markets that portion of the power that is generated from these power plants that is surplus to the amount reserved for Project Use Power (PUP) customers. Ongoing LCR operations and activities related to the generation of hydroelectric power at Hoover, Davis, and Parker Dams are conducted pursuant to a Joint Operating Agreement (JOA) between Reclamation and Western, dated February 8, 1980. This JOA was developed to implement section 302(a)(1)(e) of Public Law 95-91 (August 4, 1977). The JOA addresses maximizing the economic values of such power generation within the constraints of water release schedules, as described in Section 2.2.1.5 of the BA and Appendix S.

The quantity of water flowing through the turbines (water releases) at each dam and respective power plant determines the amount of energy that can be produced. Reclamation determines a monthly release (and energy) schedule for Lake Mead (Hoover Dam), Lake Mohave (Davis Dam), and Lake Havasu (Parker Dam) prior to the beginning of each Water Year, based on meeting the downstream water orders and other objectives pursuant to the Annual Operating Plan. The monthly schedules are revised each month to reflect changing water demands and other hydrologic conditions (See Section J.4.3.1). Water is not released solely to produce power and power contracts do not determine generation.

Once daily water orders are received from downstream water contractors, Reclamation determines the daily releases at Davis and Parker Dams and coordinates with Western to determine the hourly water release schedules. This “shaping” or scheduling of the hourly water releases throughout the day and week help to optimize power generation while still meeting the downstream water delivery orders. Reclamation operates the power plants so as to schedule and make available electrical power and energy as requested by Western, provided that compliance with such request and the operation of the power plants do not conflict with Reclamation’s requirements for the operation of the dams and power plants with regards to flood control, navigation, water deliveries, or other project purposes having a higher priority. See Section J.4.3.3 for a further discussion of daily water operations.

To the degree that storage capacity is available, Lake Mohave is used to store flows released from Hoover Dam for power generation purposes until water is required to be released to meet scheduled water deliveries to downstream water contractors in the United States and Mexico. This is possible because of the close proximity of Lake Mohave to Hoover Dam and the storage capacity usually available at Lake Mohave. Therefore, releases from Hoover Dam are restricted to meet the monthly water release schedule, not daily water release schedules such as at Davis and Parker Dams. Western’s real-time dispatchers work directly with Reclamation’s Hoover Dam operators to manage power operations dynamically. These real-time operations are described in further detail in Section J.4.3.3.

J.4.2 Annual Operations—Water Delivery Requirements to U.S. Users and Mexico

J.4.2.1 Annual Operating Plan

The Colorado River Basin Project Act (CRBPA) required the Secretary to adopt long-range operating criteria for the Colorado River by January 1, 1970. The *Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs pursuant to the Colorado River Basin Project Act of September 30, 1968* (LROC) adopted in 1970 directs the operation of the Colorado River reservoirs in compliance with requirements set forth in the Colorado River Compact, the CRBPA, the BCPA, the 1944 Water Treaty, and other applicable Federal decrees and laws. Further information on the Law of the River is presented in Appendix A. The LROC are implemented by the Secretary through decisions described in the Annual Operating Plan (AOP), which is mandated by the CRBPA.

The AOP is prepared annually by Reclamation in consultation with the Basin States, other Federal agencies, Indian Tribes, state and local agencies, and the general public. The AOP describes how Reclamation will manage the reservoirs over the next year,[1] consistent with the LROC and the Decree. Information is gathered to develop an AOP, as required by the CRBPA, after taking into consideration probable runoff, depletions, and consumptive uses.

The AOP includes determinations of:

1. The projected operation of the Colorado River reservoirs to satisfy project purposes under varying hydrologic and climatic conditions;
2. The quantity of water considered necessary as of September 30, of the next year, to be in storage in the Upper Basin reservoirs as required by section 602(a) of the Colorado River Basin Project Act;
3. The water available for delivery to Mexico pursuant to Minute No. 242 of the 1944 Water Treaty;
4. Whether the reasonable consumptive use requirements of mainstream users in the Lower Division States will be met under a Normal (delivery of 7.5 maf), Surplus (delivery greater than 7.5 maf) or Shortage (delivery less than 7.5 maf) condition as outlined in Article III of the Long Range Operating Criteria; and
5. Whether water apportioned to, but unused by one or more Lower Division States exists and can be used to satisfy beneficial consumptive use requests of mainstream users in other Lower Division States as provided in the 1964 U.S. Supreme Court Decree in *Arizona v. California*.

Since the hydrologic conditions of the Colorado River can never be completely known in advance, the AOP addresses the possible water supply and operating conditions that may result from three different hydrologic scenarios; the probable maximum (high inflow), most probable (average inflow) and probable minimum (low inflow) reservoir inflow conditions. The annual determinations listed in items 1 through 5 above are based on projected water use requirements, existing storage conditions, and most probable inflows. Pursuant to LROC, the Secretary may revise the annual determinations of the AOP within

[1] Within the Lower Basin, pursuant to the Decree, the determinations of unused apportionment, normal, surplus, and shortage deliveries are made annually on a calendar year basis. Pursuant to the LROC, hydrologic determinations in the Upper Basin, such as reservoir equalization, are based on the water year (October–September). In the AOP, which addresses both Upper and Lower Basin operations, references to *year* are expressly named *calendar* or *water*. Reclamation finalizes the AOP each year as close as possible to October 1, but the AOP is generally in effect through the following calendar year (i.e., a 15-month period). For example, the 2005 AOP would be in effect from October 2004 through December 2005.

the year to reflect current hydrologic conditions, with appropriate consultation with the Basin states and other parties, as required by law.

J.4.2.2 Water Delivery Requirements to Lower Basin U.S. Contractors

As discussed above, the Secretary, through Reclamation, is required to determine the amount of Colorado River water available to the Lower Division States for the year. In a Normal year, sufficient Colorado River water is available for release, as determined by the Secretary, to satisfy up to 7.5 maf of annual consumptive use in the Lower Division States.

In a Surplus year, sufficient Colorado River water is available for release, as determined by the Secretary, to satisfy annual consumptive use in the Lower Division States in excess of 7.5 maf. The Secretary adopted a Record of Decision (ROD) incorporating final Interim Surplus Guidelines (ISG) on January 16, 2001[2]. The ISG supplement the more general factors provided in the LROC and are to be applied by the Secretary in the development of the AOP for the 15-year period beginning in the 2002 AOP and through preparation of the 2016 AOP. The ISG established elevation "triggers" at Lake Mead that are used to determine whether surplus conditions exist, and if so, the amount of surplus water available to each Lower Basin state and for what uses it may be applied. In the ISG ROD, the Secretary also determined the method to distribute unused apportionment that may be available during the 15-year period in which the ISG are in effect. See the Record of Decision, Colorado River Interim Surplus Guidelines; Final Environmental Impact Statement, January 16, 2001, for further detail about the ISG.

In a shortage year, insufficient Colorado River water is available for release, as determined by the Secretary, to satisfy the annual consumptive use of 7.5 maf in the Lower Division States. There are no established shortage guidelines that define when Lower Basin users would receive shortage condition deliveries or the precise volume of the shortage restriction. To date, no shortage conditions in the Lower Basin have been declared.

J.4.2.3 Water Delivery Requirements to Mexico

Mexico is entitled to receive 1.5 million acre-feet per year (mafy) of Colorado River water delivered at the Northerly International Boundary (NIB) and SIB consistent with the 1944 Water Treaty (see LCR MSCP BA, Section 2.2.1.7). At least 1.36 maf are required to be delivered at the NIB (normally consisting of releases from Colorado River system storage and drainage returns) and up to 140,000 af of Colorado River water (normally consisting of drainage returns and wasteway flows) can be delivered at the SIB. Under current practice, Mexico may increase its annual water order by up to 200,000 af for a total of 1.7 maf when flood control releases are being made from Lake Mead/Hoover Dam, as described in Section J.4.1.1. Pursuant to the 1944 Water Treaty,

[2] The ISG were the subject of a previously completed ESA consultation. See also Section 2.2.2.1 of the LCR MSCP BA.

water deliveries to Mexico would be reduced in proportion to the reduced consumptive use in the United States under conditions of “extraordinary drought.” To date, no conditions of “extraordinary drought” have been determined.

Minute No. 242 of the 1944 Water Treaty defines the salinity concentration limits of Colorado River water delivered to Mexico. Reclamation has a salinity monitoring program whereby it routinely samples and measures the salinity of the river water at various points between Parker Dam and the SIB. From these monitoring and testing activities, Reclamation is able to project throughout the year the annual salinity concentration in the Colorado River water that will be delivered to Mexico. During the year, Reclamation may implement a variety of measures to reduce salinity, including, but not limited to, reducing drainage pumping, discharging the drainage flows to the Main Outlet Drain or its extension, or by changing the point of discharge of the drainage flows from the NIB to the SIB.

J.4.3 Monthly and Daily Operations

Releases originating from Hoover Dam are determined in one of two ways:

- Operations for Flood Control; releases from Hoover Dam are set by the flood control regulations (described below),
- Operations to Meet Downstream Demands; releases from Hoover Dam are set to meet the downstream water demands of Lower Basin Colorado River water entitlement holders and Mexico, as well as downstream regulation requirements (i.e., target lake levels at Havasu and Mohave, downstream losses, etc.)

J.4.3.1 24-Month Study

Colorado River operations under the AOP are adjusted during the year as runoff projections and water orders are updated. Prior to the beginning of the calendar year, diversion schedules are requested from water contractors in the Lower Division States entitled to Colorado River water and are approved by Reclamation pursuant to applicable Federal law and regulations (e.g., 43 C.F.R. Part 417). These schedules, along with the forecast of water supply, are input to Reclamation’s monthly operational model (the “24-month Study”). As the year progresses, the model is updated each month to reflect reported and projected water use for the year and to incorporate updates to the inflow forecast. The model is then re-run to produce an updated plan of operations for the main stem reservoirs. This updated plan includes projected releases and energy generation for each reservoir. In the Lower Basin, these data are provided to Western for updating their resource integration plans for the remainder of the year.

Similarly, in December of each year, Mexico provides the U.S. with an advance monthly water order for the following year. This water order can only be changed by providing the U.S. 30 days advance notice, and each monthly water order can be increased or decreased by no more than 20 percent of the original monthly water order. The 1944 Water Treaty further stipulates that Mexico’s total water order must be no less than

900 cfs and no more than 5,500 cfs during the months of January, February, October, November, and December. During the remainder of the year, Mexico's water order must be no less than 1,500 cfs and no more than 5,500 cfs.

Actual monthly releases from Hoover, Davis, and Parker Dams are adjusted to reflect the daily water delivery orders submitted by the water contractors, as well as other operational constraints.

J.4.3.2 Operations for Flood Control

At Hoover Dam, flood control releases are defined as releases in excess of the downstream demands and as required by the flood control regulations described below.

Flood control was specified as a primary project purpose by the Boulder Canyon Project Act, the act authorizing Hoover Dam. The U.S. Army Corps of Engineers (Corps) is responsible for developing the flood control operation plan for Hoover Dam and Lake Mead as indicated in 33 C.F.R. §208.11 and the plan is the result of a coordinated effort by the Corps and Reclamation. However, any deviations from the flood control operating instructions provided by the plan must be authorized by the Corps. The Secretary is responsible for operating Hoover Dam in accordance with these regulations.

The Los Angeles District of the Corps published the current flood control regulations in *Water Control Manual for Flood Control, Hoover Dam and Lake Mead Colorado River* dated December 1982 (Water Control Manual). The Field Working Agreement between the Corps and Reclamation for the flood control operations of Hoover Dam and Lake Mead, as prescribed in the Water Control Manual, was signed on February 8, 1984 (Appendix P). The Field Working Agreement is designed to ensure a clear understanding of flood control regulations and to facilitate the exchange of information between the Corps and Reclamation that is required for operation of Hoover Dam and Lake Mead.

Hoover Dam and Lake Mead

Lake Mead's uppermost 1.5 maf of storage capacity, between elevations 1,219.61 msl and 1,229.0 msl, is defined as exclusive flood control space. Within this capacity allocation, 1.218 maf of flood storage is above elevation 1,221.0 msl, which is the top of the raised spillway gates.

Flood control regulations specify that once Lake Mead flood releases exceed 40,000 cfs, the releases shall be maintained at the highest rate until the reservoir drops to elevation 1,221.0 feet msl. Releases may then be gradually reduced to 40,000 cfs until the prescribed seasonal storage space is available.

The regulations set forth two primary criteria for flood control operations related to snowmelt: 1) system space building requirements in the fall, and 2) application of runoff forecasts to determine releases in the spring.

In preparation for each annual season of snow accumulation and associated runoff, progressive expansion of total Colorado River system reservoir space is required during the latter half of each year. Minimum available flood control space increases from 1.5 maf on July 31 to 5.35 maf on January 1. Required flood storage space can be accumulated within Lake Mead and in specified upstream reservoirs: Powell, Navajo, Blue Mesa, Flaming Gorge and Fontenelle. The minimum required to be reserved exclusively for flood control storage in Lake Mead is 1.5 maf. Table J-2 presents the amount of required flood storage space within the Colorado River system by date.

Table J-2. Minimum Required Colorado River System Storage Space

Date	Storage Volume (million acre-feet)
August 1	1.50
September 1	2.27
October 1	3.04
November 1	3.81
December 1	4.58
January 1	5.35

Normal space-building releases from Lake Mead to meet the required July 31 to January 1 flood control space are limited to a maximum of 28,000 cfs. Releases in any month based on water entitlement holders’ demand are much less than 28,000 cfs (5,000 cfs to 20,000 cfs).

The Secretary may also consider additional space-building releases (described as anticipatory flood control releases) beyond the minimum requirements specified by the Field Working Agreement after consideration of other factors including channel capacity and maintenance downstream, power plant maintenance requirements at Hoover, Davis, and Parker Dams, and hydrologic conditions and forecasts.

Between January 1 and July 31, flood control releases, based on forecasted inflow, may be required to prevent filling of Lake Mead beyond its 1.5 maf minimum space requirement. Beginning on January 1 and continuing through July, the Colorado Basin River Forecast Center (CBRFC) issues monthly runoff forecasts. These forecasts are used by Reclamation in estimating releases from Hoover Dam. The release schedule contained in the Corps’ regulations is based on increasing releases in six steps as shown on Table J-3.

Table J-3. Minimum Flood Control Releases at Hoover Dam

Step	Release (cubic feet per second)
Step 1	0
Step 2	19,000
Step 3	28,000
Step 4	35,000
Step 5	40,000
Step 6	73,000

The lowest step, 0 cfs, corresponds to times when the regulations do not require flood control releases. Hoover Dam releases are then made to meet water and power objectives. The second step, 19,000 cfs, is based on the power plant capacity of Parker Dam. The third step, 28,000 cfs, corresponds to the Davis Dam Power Plant capacity. The fourth step in the Corps release schedule is 35,000 cfs. This flow corresponds to the power plant flow-through capacity of Hoover Dam in 1987. However, the present power plant flow-through capacity at Hoover Dam is 49,000 cfs. At the time Hoover Dam was completed, 40,000 cfs was the approximate maximum flow from the dam considered to be non-damaging to the downstream streambed. The 40,000 cfs flow now forms the fifth step. Releases of 40,000 cfs and greater would result from low-probability hydrologic events. The sixth and final step in the series (73,000 cfs) is the maximum controlled release from Hoover Dam that can occur without spillway flow.

Flood control releases are required when forecasted inflow exceeds downstream demands, available storage space at Lakes Mead and Powell, and allowable space in other Upper Basin reservoirs. This includes accounting for projected bank storage and evaporation losses at both lakes, plus net withdrawal from Lake Mead by the SNWA. The Corps regulations set the procedures for releasing the volume that cannot be impounded, as discussed above.

Average monthly releases are determined early in each month and apply only to the current month. The releases are progressively revised in response to updated runoff forecasts and changing reservoir storage levels during each subsequent month throughout the January 1 to July 31 runoff period. If the reservoirs are full, drawdown is accomplished to vacate flood control space as required.

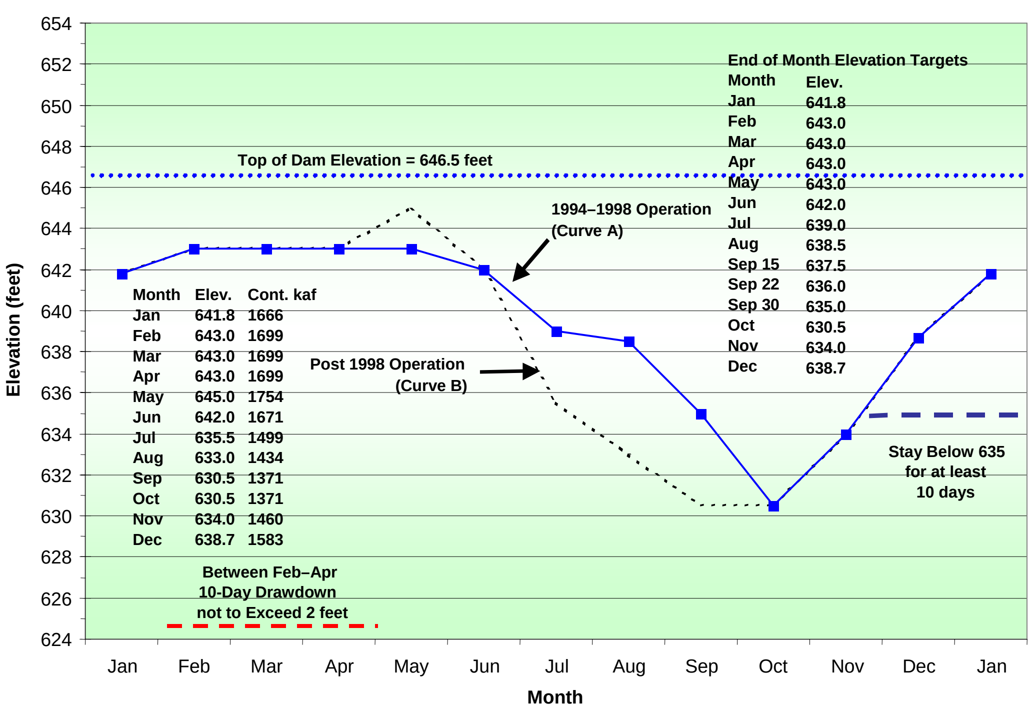
During non-flood operations, the end-of-month Lake Mead elevations are driven by consumptive use needs, Glen Canyon Dam releases, and 1944 Water Treaty deliveries to Mexico. Lake Mead end-of-month target elevations are not fixed as are the end-of-month target elevations for Lake Mohave and Lake Havasu. Normally, Lake Mead elevations decline with increasing irrigation deliveries through July and then begin to rise again. Lake Mead's storage capacity provides for the majority of Colorado River regulation from Glen Canyon Dam to the border with Mexico.

Davis Dam and Lake Mohave

Hoover Dam flood control releases are passed through Davis Dam. Flood control requirements for Davis Dam were developed through the monthly target elevations developed for Lake Mohave. System flood control releases (from Hoover Dam), as well as side wash inflows, were considered in the development of the target elevations. Reclamation has discretion to develop and manage Lake Mohave's target water surface elevations and allocated flood control reserved capacity that changes throughout the year by making releases through Davis Dam. This flood control reserved capacity is considered and taken into account in the Davis Dam release calculation. Specifically, the operators use a rule curve with "target water surface elevations" that coincide with respective vacant storage capacity. The target water surface elevations that are used to assure that sufficient flood control storage capacity is allocated for Lake Mohave are shown in Figure J-4. As shown on this figure, Lake Mohave generally reaches its maximum elevation in the spring and its minimum elevation in the fall. Reclamation generally lowers the lake level in the fall to provide flood control storage space for runoff that results from large hurricane-type storms coming up river from Mexico. However, it needs to be noted that these are target elevations only. The actual water surface elevations will sometimes differ from the target elevations with the regulation of Hoover releases and the balancing of arriving flows with downstream water demands.

As with releases from Hoover Dam, factors that must be considered when making the Davis Dam releases include the need to meet downstream water requirements throughout the month and the objective to maintain non-damaging flow levels downstream.

Figure J-4
Lake Mohave Monthly Target Elevation



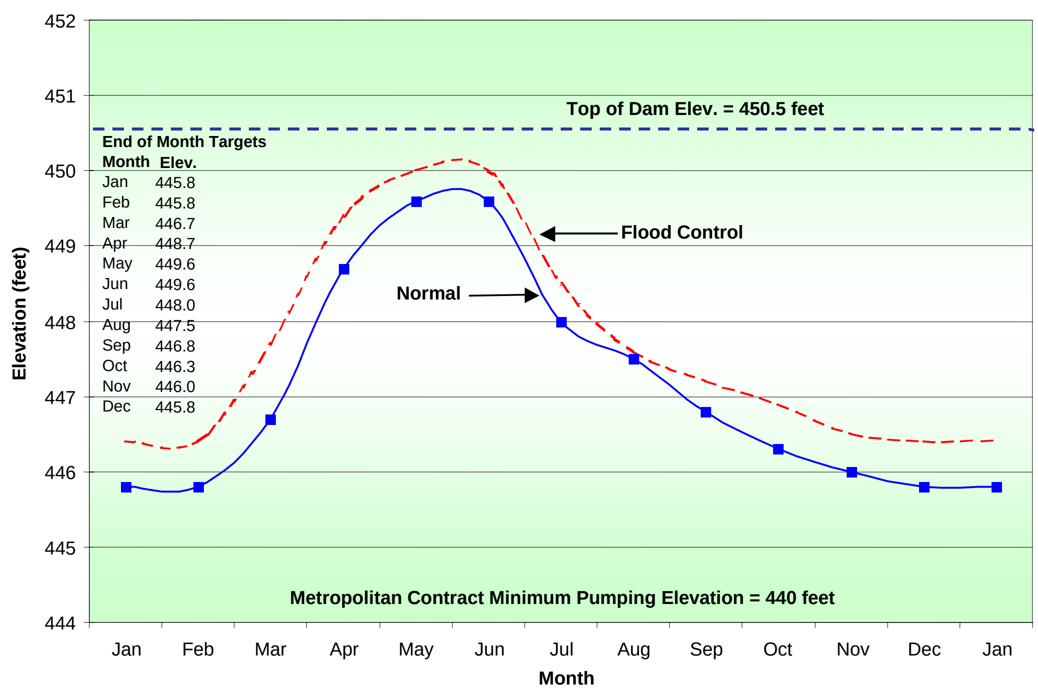
Parker Dam and Lake Havasu

Hoover Dam flood control releases also are passed through Parker Dam after deliveries are made to the CAP and Metropolitan diversion facilities at Lake Havasu, and other users upstream of Parker Dam. Flood control requirements for Parker Dam were developed through the monthly target elevations developed for Lake Havasu. System flood control releases from Hoover Dam, as well as side wash inflows and flood flows on the Bill Williams River, were considered in those target elevations. Reclamation has discretion to develop and manage the target elevations of Lake Havasu by making releases through Parker Dam.

Similar to Lake Mohave, Lake Havasu follows a target elevation curve for end-of-month water surface elevations as shown in Figure J-5. As shown on this figure, Lake Havasu generally reaches its maximum elevation in the spring and its minimum elevation in the late fall.

As with releases from Hoover and Davis Dams, factors that must be considered when making these releases include the need to meet downstream water requirements throughout the month and the objective to maintain non-damaging flow levels downstream.

Figure J-5
Lake Havasu Monthly Target Water Surface Elevations
Used to Provide Flood Control Reserve Capacity



Yuma Area Operations

In the Yuma area, under flood control conditions (due to excessive flows from any one or a combination of the main stem of the Colorado River, Bill Williams River, and or Gila River), water may be routed in any one or a combination of routes available to Reclamation to avoid flood damage in the Yuma Division. Although flood control operations at Hoover Dam is a nondiscretionary action, the specific routing of these and other flood flows through the Yuma Division is discretionary.

The flood flow routing in and around the Yuma Division can be accomplished using any one or a combination of the following methods:

- Flood flows are diverted at Imperial Dam, conveyed through the All-American Canal to the Pilot Knob Check, and at a point above the Pilot Knob Check, the flows are diverted from the All-American Canal through the Pilot Knob Power Plant and Wasteway and routed back into the Colorado River. The Pilot Knob Wasteway channel discharges to the Colorado River at a point located approximately 2.1 miles upstream of NIB.
- Flood flows are diverted at Imperial Dam, conveyed through the All-American Canal to the Siphon Drop, and at a point above the Siphon Drop, the flows are diverted from the All-American Canal through the Siphon Drop Wasteway and into the Yuma Main Canal. The water is then conveyed some 3.5 miles within the Yuma Main Canal and then is diverted and discharged back into the Colorado River via the Yuma Main Canal Wasteway. The Yuma Main Canal Wasteway (California Wasteway) discharges to the Colorado River at a point located approximately 7.6 miles upstream of NIB.
- Flood flows are passed through Imperial and Laguna Dams and allowed to flow via the river channel to NIB.

The Colorado River channel in the Yuma and Limitrophe Divisions has experienced considerable sediment aggradation (i.e., build-up) as a result of floodflows from the Gila River in 1993. Sediment that was deposited in these reaches of the river has raised streambed and groundwater elevations. The area that has been impacted most recently is the 34-mile portion of the river from the confluence with the Gila River through the Yuma and Limitrophe Divisions to the SIB. During the Gila River flood of 1993, an estimated 10 million cubic yards of sediment was deposited in the Yuma Division, the reach of the river from the confluence with the Gila River to Morelos Diversion Dam. The aggradation of the river channel increased normal flow elevations an average of approximately five feet and increased groundwater levels in the Yuma area between two and five feet above normal, depending on the location and its proximity to the Colorado River.

During 1999 and 2000, the portion of the Colorado River from Pilot Knob Wasteway to Morelos Diversion Dam was dredged by Reclamation to improve channel capacity and reduce sediment inflow to Mexico’s canal system. Reclamation estimates that the river reach between the Pilot Knob Wasteway and the Morelos Diversion Dam currently has a flow capacity of about 18,000 cfs.

The river reach between the Pilot Knob Wasteway to the Gila River has not been dredged since the Gila River flood of 1993. As such, the flow capacity of this river reach is now less than that available before 1993. In the latter part of 2000, Reclamation developed an estimate of the channel capacity in the Yuma area above Pilot Knob Wasteway. These estimates indicate that this river reach may accommodate flows of approximately 9,000 cfs before facilities located within the levee system would be damaged. Due to the capacity limitations in this river reach, Reclamation will, to the extent possible, use alternative routing of surface waters around the Yuma area to decrease the possibility of significant damage to federal, state, local, and private facilities, Indian reservation lands, and other potential sites. Alternative routing provides a means of minimizing the impacts of flood flows.

Using the above described alternative flood flow routing methods, flood flows that arrive at Imperial Dam in excess of 9,000 cfs can be diverted from the mainstem at Imperial Dam and routed through the All-American Canal. These flood flows can then be returned to the mainstem of the Colorado River via the Pilot Knob Power Plant and/or Pilot Knob Wasteway, via the Siphon Drop Power Plant and Yuma Main Canal, or a combination of these two routes. The All-American Canal is used principally to convey Imperial Irrigation District's and Coachella Valley Water District's Colorado River entitlement from the Colorado River at Imperial Dam to their respective service areas.

The All-American Canal can convey flows up to 12,000 cfs between Imperial Dam and Pilot Knob. During flood flow conditions, the magnitude of the flood flows that can be routed through the All-American Canal are constrained by this maximum flow capacity (12,000 cfs) and the scheduled water deliveries of the Imperial Irrigation District and Coachella Valley Water District. The combined Imperial Irrigation District and Coachella Valley Water District water deliveries can vary between a few hundred cfs to as much as 8,000 cfs. As such, Reclamation can route flood flows through the All-American Canal that equal the difference between 12,000 cfs and the scheduled water deliveries for Imperial Irrigation District and Coachella Valley Water District. The remainder of the flood flows would be passed through Imperial and Laguna Dams and routed to NIB via the river channel.

Any flood flows that arrive at Morelos Dam are available to water contractors in Mexico for diversion at Morelos Diversion Dam. The maximum capacity of Mexico's diversion canal, the Reforma (formerly Alamo) Canal, is 5,500 cfs. Any flow that Mexico does not divert to the Reforma Canal at Morelos Diversion Dam would pass Morelos Diversion Dam and enter the river channel in the Limitrophe Division.

Table J-4 provides an example of this flood flow routing process. The numbers in these tables are provided for example purposes only. The actual flood flow routing would need to be determined based on a range of factors and conditions that exist at the time that these decisions are needed to be made. In this example, by deducting the estimated water orders, river losses, and water placed in storage downstream of Hoover Dam from the planned flood flow release from Hoover Dam, it is possible to determine the amount of water that will arrive at Imperial Dam. By deducting the scheduled water deliveries at Imperial Dam, it is possible to determine how much water must be released from Imperial Dam to the downstream river reach, either by passing the water through Imperial and Laguna Dams or by routing the water via the All-American Canal. The latter requires the operators to determine how much capacity is available in the All-American

Canal to carry a portion of the flood flows around the Yuma area. In general, the practice is to maximize the releases from the All-American Canal through Pilot Knob Power Plant and Wasteway to the extent possible, with the remaining releases routed through the river channel by passing the water through Imperial Dam and Laguna Dam.

Table J-4. Hypothetical Scenario for Flood Routing Resulting from Flood Control Releases—Stream Channel

Flow (cubic feet per second)	Release or Diversion Location
28,000	Hoover Dam Flood Flow Release
0	Stored in Lakes Havasu or Mohave
-2,000	Metropolitan Water District order
-3,000	Central Arizona Project order
23,000	Parker Dam Flood Flow Release
-400	Colorado River Indian Tribes order
-300	Palo Verde Irrigation District order
-800	System losses (e.g., evaporation)
21,500	Flood Flow Arriving at Imperial Dam
-3,000	Imperial Irrigation District/Coachella Valley Water District orders
-400	Yuma County Water Users' Association order
-200	Reservation Division order
-700	Gila Gravity Main Canal Station 30 order
17,200	Estimated Flood Flow Needed to be Routed to NIB
8,000	Calculated Portion of Flood Flow to be Routed to NIB via All-American Canal and Pilot Knob
400	Calculated Portion of Flood Flow to be Routed to NIB via All-American Canal and Siphon Drop
8,800	Calculated Portion of Flood Flow to be Routed to NIB via River Channel
17,500	Flood Flow Arriving at NIB (including 300 drainage flow)
-3,000	Morelos Diversion Dam diversion (5,500 maximum)
14,500	Released to Limitrophe Division

In the example shown above, all of the unused available capacity of the All-American Canal is used to convey a portion of the flood flow (8,400 cfs) that arrives at Imperial Dam. The remainder of the flood flow (8,800 cfs) is passed through Imperial and Laguna Dams and routed to NIB via the river channel. In this example, 400 cfs of the flood flow being routed via the All-American Canal is returned to the river via the California Wasteway and the remainder (8,000 cfs) is returned to the river via the Pilot Knob Power Plant and Wasteway.

During prolonged flood control releases, water is not normally stored in Lakes Mohave or Havasu. However, for short-term flood control releases lasting only a few days or weeks, some water may be stored in Lake Havasu and Lake Mohave to provide relief to downstream reaches of the river to the extent possible. In addition, storage available at Imperial Dam, Senator Wash, and Laguna Dam is often used, on a day-to-day basis, to delay the full impact of flood releases in the Yuma area for that length of time.

The above described alternative flood flow routing methods have been used intermittently since 1983 and most recently during flood control release periods in 1997, 1998, and 1999. These alternative routing methods are expected to be used again under future high-flow conditions. This alternative approach to flood routing is a discretionary approach to river flow management and is needed to reduce or prevent flood damage and to facilitate nondiscretionary water deliveries.

J.4.3.3 Operations to Meet Downstream Water Demands

This section provides an overview of the processes used by Reclamation to schedule daily water releases and energy production under non-flood control conditions. The goal of Reclamation is to provide water for beneficial use and to maximize power generation to the extent practicable within the Law of the River. This is done through a very deliberate and well-coordinated process that involves various Reclamation offices, Western, other governmental and non-governmental organizations, and private entities.

The description of the daily operations is provided on a bottom-to-up sequence; i.e., the daily scheduling begins with the demands of the users located at the lowest part of the river and these are accumulated with the demands of the users located in the upstream river reaches. This process is used to calculate and schedule releases from each reservoir in sufficient quantities to meet the water delivery requirements of the respective downstream users.

Yuma Area Operations

Reclamation’s Yuma Area Office schedules water deliveries from Parker Dam to users in southern Arizona, southern California, and Mexico. This office also operates four drainage well fields located in the Yuma area and coordinates the operation of two other drainage well fields operated by or owned by other water agencies. Additionally, Reclamation manages all salinity control projects south of Imperial Dam to meet the salinity requirements of flows delivered to the Northerly and Southerly International Boundaries with Mexico. The following provides more detail on Reclamation’s Yuma Area Operations.

Water Scheduling and Water Deliveries

The Yuma Area Office administers Colorado River water deliveries downstream of Davis Dam, except for water diverted from the river and conveyed to the Southern California coastal plain and to Central Arizona. As noted previously, water released from Hoover Dam is regulated in Lake Mohave and releases from Davis Dam are regulated in Lake Havasu. The transit time for water released at Hoover Dam to reach Lake Havasu is less than two days. Water released from Parker Dam (and Lake Havasu) takes approximately three days to travel to Imperial Dam.

Reclamation evaluates several factors in determining how much water to release from Hoover, Davis, and Parker Dams. These factors include: water orders obtained in advance of the release of such water from the Dam, trends in the water orders (i.e., are they going up, down, or remaining fairly constant), drainage return flows, current and projected weather forecasts, downstream river losses or gains, and the current and projected status of storage at Senator Wash Reservoir, behind Imperial Dam, and behind Laguna Dam. Also, different reservoir elevations apply according to the time of year due to varying river regulation needs, and partly to accommodate environmental and recreational considerations.

U.S. water entitlement holders below Parker Dam submit their water orders to the Yuma Area Office on each Wednesday of every week. However, U.S. water entitlement holders are able to adjust their master schedule of water orders up to three days prior to the schedule water release from Parker Dam. In addition to this, they are also permitted to vary from their master schedule on a daily basis, if needed. The daily volume of water released from Parker Dam is made to meet the water ordered by Mexico and U.S. users and includes gains and losses that occur along the river from Parker Dam to Imperial Dam.

Upstream of Imperial Dam, due to the shorter travel time between Parker Dam and their respective diversion structure, the Palo Verde Irrigation District may modify its order one day in advance of water releases from Parker Dam, and the Colorado River Indian Reservation may modify its order essentially on the same day as it is delivered at Headgate Rock Diversion Dam.

Once released from Parker Dam, there is limited capacity to regulate flows to accommodate changes in demand for water by downstream users. Water released from Parker Dam pursuant to a user’s order may be rejected by that user for the following reasons:

- Unexpected changes in weather including rain, wind, or cooler than expected temperatures.
- Unexpected damage or failure of canal facilities.
- Unexpected changes in water requests from farmers due to on-farm irrigation system problems or unexpected on-farm management problems.

Any water ordered exceeding actual demand at the time of arrival at Imperial Dam (i.e., the amount of a user’s order rejected after it has been released from Parker Dam) by any one of the downstream users is managed in one of the following ways:

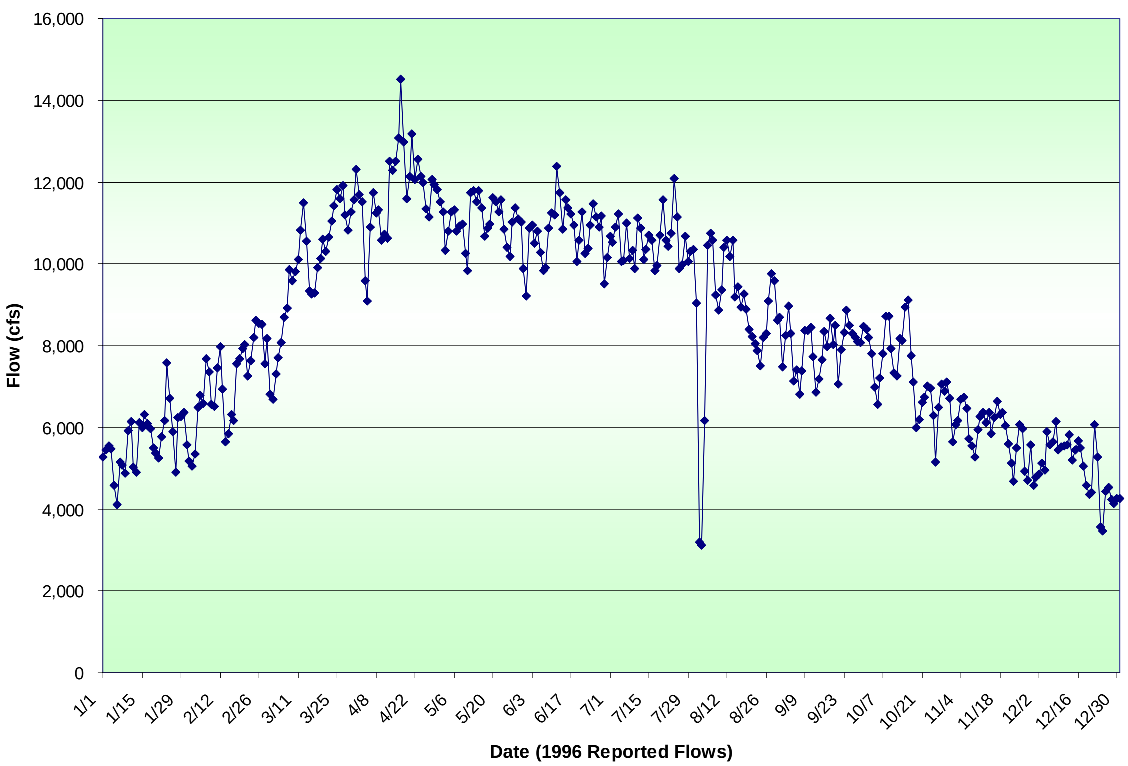
- Put in storage at Senator Wash Reservoir or behind Imperial Dam.
- Delivered to another water contractor needing to divert more water than it ordered.
- Delivered to Mexico as part of its scheduled delivery or as non-storable water.

- Routed through the Old River Channel and Laguna Dam to temporarily store the water or slow down the transit time.

Figure J-6 shows the variability of the daily flows arriving at Imperial Dam. The daily flow values shown in this figure represent actual daily flows arriving at Imperial Dam during the 1996 Calendar Year.

Any water above actual demands that arrives at Imperial Dam that cannot be managed by any or a combination of the above options is inadvertently delivered to Mexico and is considered to be non-storable water. Non-storable water may also result from infrequent and unregulated inflow from numerous desert washes that discharge into the Colorado River between Parker Dam and Imperial Dam. Flood control releases from Hoover Dam are normally in excess of downstream demands that also result in non-storable flows.

Figure J-6
Variation of Daily Flows Arriving at Imperial Dam
(reported 1996 daily river flow measurements at Cibola Stream Gage, RM 87.3)



1944 Water Treaty Delivery Requirements

The United States Section, International Boundary and Water Commission (USIBWC) Minute No. 242 of the 1944 Water Treaty, provides for the United States to deliver annually to Mexico 1.36 maf of water from the Colorado River at the NIB and up to 140,000 af at the SIB. The NIB is one mile upstream of Morelos Diversion Dam. Further, if Reclamation determines surplus water exists in excess of the amount necessary to supply uses in the United States and the guaranteed quantity of 1.5 maf annually to Mexico, Mexico may schedule up to an additional 200,000 af annually.

The 1944 Water Treaty also provides that in the event of “an extraordinary drought” or “serious accident” to the delivery system, deliveries to Mexico will be “reduced in the same proportion as consumptive uses in the U.S. are reduced.” To date, these provisions of the 1944 Water Treaty have not been invoked.

Minute No. 242 of the 1944 Water Treaty also provides that water received by Mexico at NIB will be no more than 115 ppm or, plus or minus 30 ppm, greater than the salinity of the river at Imperial Dam. This water quality requirement makes it necessary to consider the volume and water quality of the drainage return flows that enter the Colorado River below Imperial Dam and the volume and water quality of the water that is scheduled for diversion and delivery to Mexico from above Imperial Dam. In most situations, sufficient water must be released from Imperial Dam to balance the water quality of the inflows that occur below Imperial Dam.

Reclamation entered into a contract on June 14, 1972, for temporary emergency delivery of a portion of the 1944 Water Treaty waters in the vicinity of the City of Tijuana, Mexico. This contract was renewed or extended several times. The USIBWC concluded Minute No. 310 of the 1944 Water Treaty on July 28, 2003, entitled “Emergency Delivery of Colorado River Water for Use in Tijuana, Baja California,” which authorized these deliveries. Following the completion of Minute No. 310 of the 1944 Water Treaty, the most recent renewal was completed on September 29, 2003. The specifics of this agreement are discussed further in a later part of this selection.

1944 Water Treaty Deliveries at the Northern International Boundary

Under normal operating conditions and when there is no runoff from the Gila River System, the delivery of scheduled water to Mexico at the Northerly International Boundary (NIB) comes from two principal sources: 1) drainage return flows that occur downstream of Imperial Dam, and 2) the diversion of flows to Mexico from Imperial Dam. The drainage return flows are nearly constant throughout the year and from year to year and comprise both gravity and pumped drainage flows.

On Wednesday of every week, Mexico submits a schedule of daily water orders for the ensuing week. These orders are submitted to Reclamation through the International Boundary and Water Commission (IBWC), at Yuma. Mexico cannot change its daily water order once received by Reclamation, except in cases of emergency.

The Mexico diversions from Imperial Dam may be delivered to Mexico at NIB via one or a combination of three routes. Figure J-7 presents a schematic that shows these routes. The following provides an explanation of these three flow routing methods:

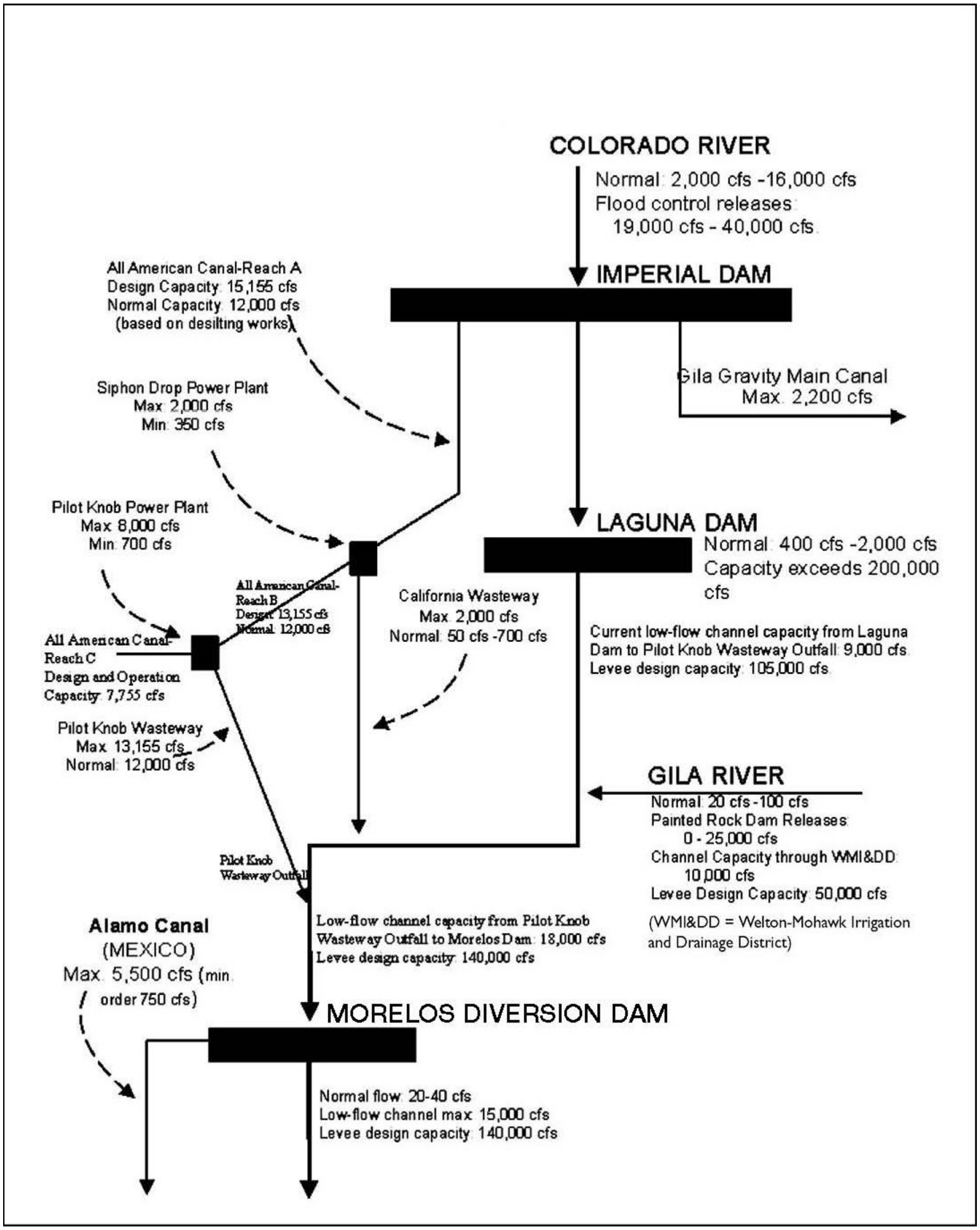
- The water scheduled to be delivered to Mexico is diverted at Imperial Dam, conveyed through the All-American Canal to the Pilot Knob Check, and at a point above the Pilot Knob Check, the flows are diverted from the All-American Canal through the Pilot Knob Power Plant and Wasteway back into the Colorado River. The Pilot Knob Wasteway channel discharges to the Colorado River at a point located approximately 2.1 miles upstream of NIB.
- The water scheduled to be delivered to Mexico is diverted at Imperial Dam, conveyed through the All-American Canal to the Siphon Drop, and at a point above the Siphon Drop, the flows are diverted from the All-American Canal through the

Siphon Drop Wasteway and into the Yuma Main Canal. The water is then conveyed some 3.5 miles within the Yuma Main Canal and then is diverted and discharged back into the Colorado River via the Yuma Main Canal Wasteway. The Yuma Main Canal Wasteway discharges to the Colorado River at a point located approximately 7.6 miles upstream of NIB.

- The water scheduled to be delivered to Mexico is delivered directly to NIB via the Colorado River. Under this method, water is passed through Imperial and Laguna Dams and is allowed to flow via the river channel to NIB. These flows are in addition to the base flows in the riverbed downstream of Laguna Dam. The base flows are generally consistent throughout the year and result from gate leakage at Imperial Dam, returns to the river below Imperial Dam from the All-American Canal Desilting Basin, and drainage flows from downstream sources. These base flows normally range from 600 cfs to 800 cfs.

Another intermittent water source that is available for delivery to Mexico at the NIB is the Gila River. When releases from Painted Rock Dam occur, these flows are used to satisfy a portion of Mexico's delivery, depending on the amount of flow from the Gila River that enters the Colorado River upstream of the NIB.

Figure J-7
Water Routing to Morelos Diversion Dam
Deliveries to Mexico Pursuant to 1944 Water Treaty



Well and Drainage Operations

A significant portion of the agricultural development that exists today in the Yuma Mesa, Yuma Valley, South Gila Valley, North Gila Valley, the Wellton-Mohawk area, and the Reservation Division began at the turn of the century. The original water supply used for these irrigated lands was principally groundwater. However, with the rapid growth of agricultural development and increasing demand for irrigation water, the groundwater supplies were quickly required to be supplemented with surface water supplies from the Colorado River.

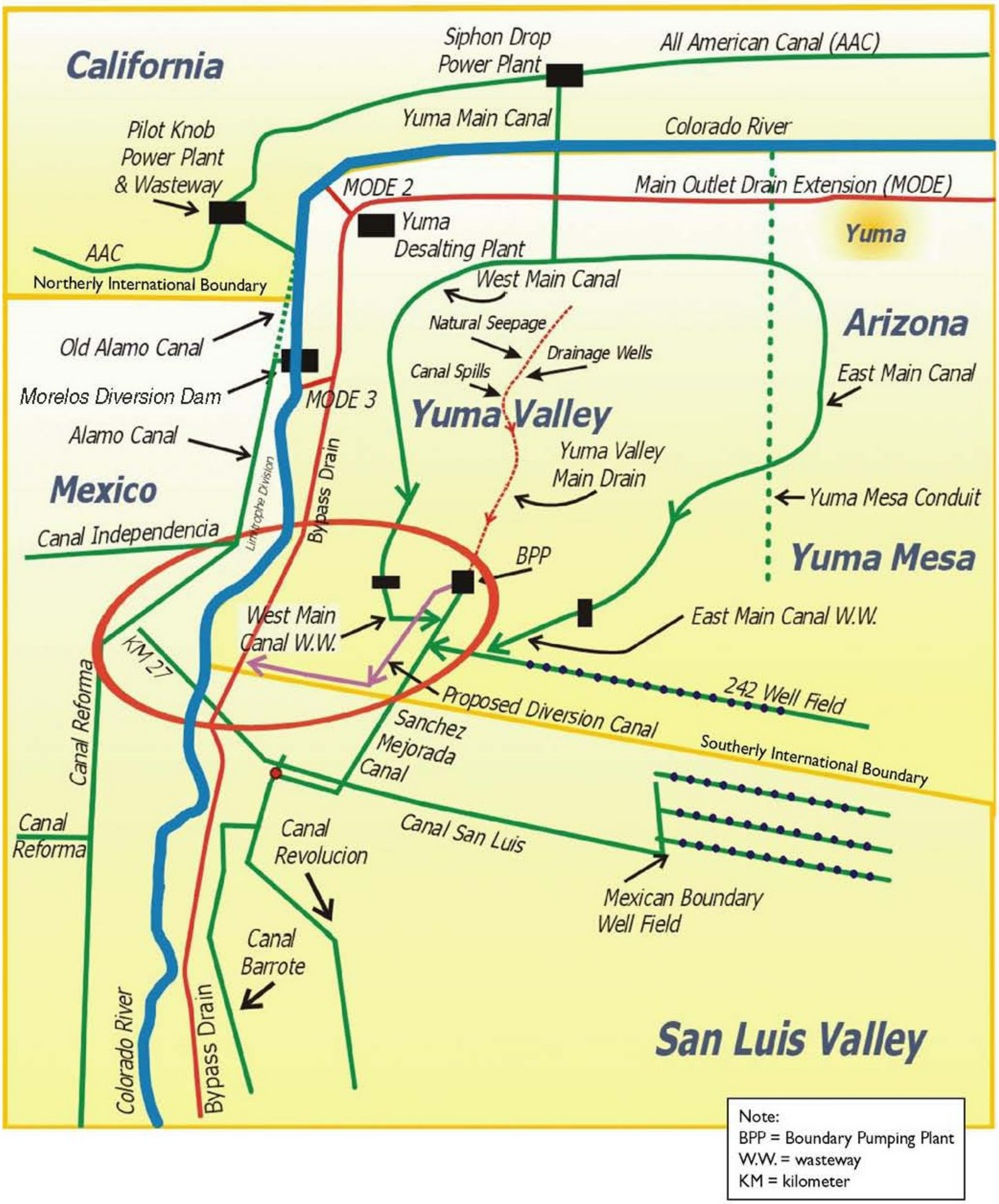
Most of these areas began to have drainage problems soon after delivery of Colorado River water began. The drainage problems can be attributed to various factors including:

- Irrigated areas must have either natural or artificial drainage to get rid of excess water and groundwater mounding that would otherwise "waterlog" the land.
- Natural or artificial drainage systems need to be provided to dispose of the salts that accumulate as a result of the crop's use of the water through evapotranspiration. In sufficient concentration, all salts, even fertilizers, can be injurious to plants.

For the South Gila Valley, Yuma Valley and the Wellton-Mohawk area, the rapid rate at which land was put into agricultural production, the flatness and poor natural drainage conditions of the lands, the magnitude of the need to leach ("flush") the naturally salty soils, the water application requirements made necessary by high temperatures and light soils, and the nature of the underlying aquifer made the installation of a drainage (return flow) system a requirement soon after Colorado River water was first applied to the land. In addition to this, the application of irrigation water on Yuma Mesa lands created a groundwater mound which exacerbated the groundwater problems in the South Gila and Yuma Valleys. As such, Reclamation and the various irrigation districts that operate in and around these lands have constructed, over the years, various drainage systems that are used today to facilitate the drainage of the affected lands. The areas served by these systems include the service areas of the Bard Water District (Bard – i.e., Reservation Division), North Gila Valley Irrigation and Drainage District (NGVID—i.e., North Gila Valley), Yuma Irrigation District (YID—i.e., South Gila Valley), The Wellton-Mohawk Irrigation and Drainage District (WMIDD), and the Yuma County Water Users Association (YCWUA—i.e., Yuma Valley). The drainage systems used to drain these lands form a network of groundwater wells, open drains, canals, pipelines, pumping systems, and related appurtenances. Figure J-8 shows the general layout of these drainage systems. Some of the facilities are operated by Reclamation, others by the overlying District, and others are jointly operated by Reclamation and one or more of the overlying districts. The principal facilities that make-up the drainage systems include:

- Wellton-Mohawk Main Conveyance Channel,
- Main Outlet Drain,
- Main Outlet Drain Extension (MODE),
- MODE 2, MODE 3, and related wasteways,
- 11 and 21 Mile Wasteways,
- U.S. and Mexican sections of the Bypass Drain,

Figure J-8
Drainage and Well Systems in the Yuma Area



- Yuma Valley Main Drain,
- East and West Main Canal Wasteways,
- Boundary Pumping Plant,
- Sanchez-Mejorada Canal,
- Yuma Mesa Conduit,
- Yuma Mesa Drainage Well Field,
- 242 Well Field,
- Reservation Division Main Drain and related drainage system,
- A diversion channel from the Boundary Pumping Plant to the U.S. Bypass Drain,
- The South Gila Valley drainage wells,
- The Yuma Valley drainage wells.

The Wellton-Mohawk Main Conveyance Channel and the Main Outlet Drain are gravity canals used to convey return flows from the lands in and around the WMIDD service area to the Colorado River. These facilities originally discharged into the Colorado River above the NIB. To improve the quality of the water that is delivered to Mexico, the Main Outlet Drain Extension (MODE) was constructed in the late 1960's. The MODE is also connected to the Bypass Drain which gives Reclamation the flexibility of discharging the return flows to the Colorado River above NIB, between NIB and SIB, or below SIB (to the Santa Clara Slough, also known as the Cienega de Santa Clara).

The Yuma Mesa Conduit was constructed to convey the discharge of the Yuma Mesa Well Field wells to the Colorado River. Since its construction, several drainage wells in the Yuma Valley have been allowed to discharge into the Yuma Mesa Conduit. The Yuma Mesa Conduit flows in a northerly direction and can discharge directly into the Colorado River (upstream of the NIB), discharge into the Yuma Valley drainage system, or discharge into the MODE.

The Yuma Valley Main Drain extends north to south through the central part of the Yuma Valley and terminates at the Boundary Pumping Plant which is located near the SIB. The Yuma Valley Main Drain has several branches and together total almost 60 miles of drainage ditches and canals. There are numerous drainage wells along the east side of the valley that intercept underground flows from the Yuma Mesa and divert seepage from cultivated lands. Several of these wells are operated and maintained by the Yuma County Water Users' Association and others by Reclamation. Most of the water pumped from the drainage wells is discharged into the open drain system which then flows into the Yuma Valley Main Drain and then to the Boundary Pumping Plant. A small quantity of the drainage water from the wells and isolated open drains is occasionally pumped into irrigation canals. In addition several of the wells in the Yuma Valley have recently had connections constructed to the Yuma Mesa Conduit.

The East and West Main Canal Wasteways are essentially extensions of the East and West Main canal systems. These wasteways are used to convey tailwater from the East and West Main canals into the Sanchez-Mejorada Canal. The Sanchez-Mejorada Canal was originally constructed to convey the discharge from the Boundary Pumping Plant to the Colorado River. This canal flows south from the Boundary Pumping Plant, crosses and then flows into Mexico, and then connects to other canals and drains that are operated by Mexico and that discharge to the Colorado River. The water from the Boundary Pumping Plant, along with water from other sources, is used by Mexico and sustains a significant agricultural economy along the east side of the Colorado River in Mexico.

Reclamation has also constructed and operates a diversion channel that extends from the Boundary Pumping Plant to the U.S. Bypass Drain. This diversion channel provides Reclamation with the flexibility to convey the discharge from the Boundary Pumping Plant to either the Sanchez-Mejorada Canal or to the U.S. Bypass Drain. This flexibility enables Reclamation to better manage the quality of the water that is delivered to Mexico at both locations.

The 242 Well Field is located east of San Luis, Arizona, in the Five-Mile Zone. The well field was authorized under Minute No. 242 of the 1944 Water Treaty and Public Law 93-320. The well field is used to manage and conserve the underlying groundwater and to provide obligated water deliveries to Mexico. The well field comprises some 21 wells, with the potential to expand to 35 wells in the future, if needed. These wells are operated by Reclamation. The well field has an existing pumping capacity of approximately 110,000 afy and the potential to be expanded to 160,000 afy in the future, if needed. The wells are strategically located within the 5 mile by 13 mile strip of land commonly referred to as the Five-Mile Zone. The discharge from the wells is conveyed to the 242 Lateral. The 242 lateral is designed as an open and closed system consisting of a pipeline on each end and an open concrete lined channel in the center. The pipeline varies from 27-inches in diameter to 72-inch. The end of the 242 Lateral is the 72-inch diameter terminal discharge pipeline that connects and discharges to Sanchez-Mejorada Canal.

Drainage pumping in the Yuma area is necessary to maintain groundwater levels that are compatible with farming and urban infrastructure including homes, businesses, streets, septic tanks, and underground utilities such as sewer and water facilities and power lines.

Drainage pumping is carefully balanced to maintain satisfactory groundwater levels while meeting the water quantity and water quality (salinity) requirements of the deliveries to Mexico at the NIB. Some drainage return flows (both gravity flows and pumped flows) are also delivered to Mexico at SIB and are discussed in the following section. Deliveries from the Yuma Mesa Conduit can be sent either to NIB or for emergency salinity control to the MODE, the Yuma Desalting Plant or a portion of the flows in the Yuma Mesa Conduit may be diverted to the SIB via opening a valve on the conduit at Avenue B ½ and County 13 ½ Streets. This valve has a capacity of approximately 30 cfs. The Yuma Mesa Conduit has a capacity of approximately 115 cfs.

Drainage water is pumped and conveyed to the river above NIB from the following well fields:

- The South Gila Valley Well Field, consists of 24 wells which pump to four Drainage Pump Outlet Channels (DPOC's) with a total maximum capacity of 114 cfs ranging in distance from 9 to 12 miles upstream of NIB. Drainage flows pumped from these wells are conveyed either to the river above NIB or the drainage flows may be bypassed around NIB via the MODE, if necessary, for salinity control. Total volume of water pumped is typically in the range of 55,000–75,000 afy. Reclamation owns, operates and maintains these wells and conveyance facilities.

- The Yuma Mesa Well Field consists of 12 wells with a current total maximum capacity of 54 cfs. Drainage flows pumped from these wells are conveyed to the river above NIB through the Yuma Mesa Conduit. Drainage from these wells may be conveyed to the Colorado River upstream of NIB, to the Yuma Valley drainage system, or to the MODE. Total volume of water pumped is typically in the range of 20,000–30,000 afy. The wells range from 8–16 miles upstream of the outlet of the Yuma Mesa Conduit. The outlet of the Yuma Mesa Conduit discharges directly into the Colorado River about 3.5 miles upstream of NIB. Reclamation owns, operates and maintains these wells.

- The Yuma County wells consist of 4 wells owned by Yuma County and 14 wells owned by Reclamation and operated and maintained by the Yuma County Water Users’ Association under contract with Yuma County. The four Yuma County wells have a maximum capacity of 24 cfs and drainage flows are conveyed to the river above NIB via the Yuma Mesa Conduit. These flows may also be conveyed to the MODE. Total volume of water pumped by the four Yuma County wells and conveyed to the river is typically in the range of 5,000–8,000 afy. The 14 Reclamation-owned wells have a maximum capacity of 64 cfs. The drainage flows from these wells can be conveyed through the Yuma Mesa Conduit, directly to the river, or to the MODE if salinity control becomes critical. These wells range from one to six miles from the Yuma Mesa Conduit outlet which is about 3.5 miles upstream of NIB. Total volume of water pumped by these wells is typically in the range of 3,000–6,000 afy. Operation of all of these wells is coordinated through Reclamation.

- The Yuma Valley drainage wells consist of seven wells with a total maximum capacity of 31 cfs. The drainage flows from these wells can be conveyed to the Yuma Mesa Conduit, the East Drain, or the Southeast Drain, depending upon which well is pumped. The wells are located 6–12 miles upstream of the Yuma Mesa Conduit outlet to the river. Total volume of water pumped by these wells is typically in the range of 20,000–30,000 afy. These wells are owned, operated and maintained by Reclamation.

- The Yuma County Water Users’ Drainage Wells consist of six wells with a total maximum capacity of 32 cfs and range in distance from 3–14 miles upstream of the Yuma Mesa Conduit outlet. Drainage flows pumped from these wells are conveyed to the river above NIB through the Yuma Mesa Conduit. Total volume of water pumped by these wells is typically about 20,000 afy. Operation of these wells is coordinated with Reclamation.

- The Yuma Area Water Resource Management Group (YAWRMG) wells consist of six wells with a total maximum capacity of 27 cfs. The drainage flows from these wells can be conveyed to the Yuma Mesa Conduit, the East Drain Extension, or the Yuma Valley Main Drain, depending upon which well is pumped. Total volume of water pumped from these wells is expected to range from approximately 12,000 afy to about 23,000 afy for the first four to six years after completion of all of the wells (estimate beginning in CY 2005), to achieve acceptable groundwater levels in the

Yuma Valley. Once acceptable groundwater levels are achieved, the groundwater pumping will be reduced to that required to maintain the desired groundwater levels.

1944 Water Treaty Deliveries at the Southerly International Boundary

As discussed above, most of Mexico's 1.5 maf annual Colorado River entitlement is delivered to Mexico at the NIB. Minute No. 242 of the 1944 Water Treaty, dated August 30, 1973, states that of the 1.5 maf that is required to be delivered by the United States to Mexico on an annual basis, up to 140,000 af of water per year can be delivered at the SIB near San Luis and in the Limitrophe Division at salinity levels historically delivered there. This salinity level is calculated on an average annual basis based upon composite water samples. These calculated salinity concentrations are compared to the historic salinity levels for water delivered to Mexico at SIB which are approximately 1,500 parts per million (ppm).

Deliveries of water to Mexico at the SIB include a mixture of flows from different sources including the 242 Well Field, the East and West Main Canal Wasteways, the Yuma Valley Main Drain via the Boundary Pumping Plant and the 11 and 21 Mile Wasteways. Water from this well field makes up a portion of the flows delivered to Mexico at the SIB. The 242 Well Field was constructed in the early 1980s and has operated intermittently since then. The well field is not operated when flood control releases or space-building releases are being made from Hoover Dam. In accordance with Minute No. 242 of the 1944 Water Treaty, the U.S. is authorized to pump up to 160,000 afy within the Five-Mile Zone, which includes the 242 Well Field. Some of the water from the well field can be delivered to private or municipal sources within the United States through contracts with Reclamation.

In late 1990s, as a matter of international comity, Reclamation agreed to address Mexico's concerns with short-term fluctuations in the quantity and quality (salinity) of water deliveries at SIB. A variable-speed motor controller was installed in 2003 on one of the four pumps at the Yuma Valley Boundary Pumping Plant to reduce variations in flows and peaks in salinity of those flows. A diversion channel from the Boundary Pumping Plant to the U.S. Bypass Drain was constructed in 2002 to discharge a portion of the highly saline Yuma Valley drainage to the Wellton-Mohawk Bypass Drain or to the Colorado River. It was agreed that the variable-speed pump would be operated throughout each year and that no more than 8,000 af of drainage water would be diverted over a four-month period (as prescribed by Mexico) within each year to reduce salinity levels delivered to Mexico at the SIB to approximately 1,200 ppm. A firm commitment on the salinity level to be achieved was not made because of the variability in conditions occurring at the SIB.

Storage in Lake Mead and Delivery to Tijuana, Mexico

In 1972, Reclamation, the USIBWC, Mexico, and several California water agencies entered into an agreement entitled "Agreement for Temporary Emergency Delivery of a Portion of the 1944 Treaty Waters of the Colorado River to the International Boundary in the Vicinity of Tijuana, Baja California, Mexico, and for the Operation of Facilities in the United States." The California water agencies that are signatories to this agreement include: Metropolitan, the San Diego County Water Authority (SDCWA), and the Otay Water District (Otay).

Pursuant to this agreement, the California water agencies agreed to convey and deliver through their respective water conveyance systems, a portion of Mexico's water entitlement from the Colorado River to the City of Tijuana and its surrounding area. This emergency delivery of Colorado River water to the City of Tijuana constitutes a change in point of delivery and diversion of a portion of Mexico's 1944 Water Treaty waters from the NIB to Lake Havasu.

The subject water is diverted by Metropolitan through its Colorado River Aqueduct at Lake Havasu. Pursuant to the terms and conditions of this agreement, Metropolitan and the other water districts act solely as an agent of the United States for the purpose of providing a portion of the 1944 Water Treaty deliveries to the City of Tijuana and do not create an entitlement to Colorado River water for any party to the contract. The water diverted for this purpose is not consumptively used by the districts. The water is conveyed to the City of Tijuana through the conveyance systems of Metropolitan, SDCWA, and Otay. The Tijuana State Public Services Commission pays all financial costs incurred in making these deliveries. The emergency deliveries are made in the interest of international comity to strengthen the bonds of friendship between the United States, Mexico, and the City of Tijuana. The emergency deliveries are necessary for the health and welfare of the people of the City of Tijuana and help to reduce the threat of epidemic diseases that might result from water shortages.

Under the agreement for temporary emergency deliveries, the maximum monthly volume of emergency deliveries for the City of Tijuana at the service connection between Mexico and Otay is approximately 1,200 af per month and 14,400 afy. To make emergency deliveries more reliable, the contract provides Metropolitan flexibility in scheduling its diversions of Colorado River water. Metropolitan is permitted to divert additional water at its point of diversion from the Colorado River, over and above its entitlement amount, in the amount equal to the quantities of water diverted for the emergency deliveries to the City of Tijuana. The additional water that Metropolitan is permitted to divert is limited to the estimated requirement for the succeeding calendar year (or an additional 14,400 af). This flexibility will maximize the use of available storage capacity during the term of this contract by allowing the diverted excess water to be stored in reservoirs within Metropolitan's service boundaries for delivery in a future year. In any specific time period, this storage may result in slightly greater diversions from Lake Havasu than otherwise would occur.

While the contract for emergency delivery to Tijuana is in effect, Reclamation will not charge the water stored in Metropolitan's system against Metropolitan's own right to delivery of Colorado River water but will charge it against Mexico's 1944 Water Treaty water in the year the emergency deliveries are made to Tijuana. If Metropolitan has any water in storage that had been intended for future delivery to Mexico pursuant to the contract for emergency delivery to the City of Tijuana when the contract terminates, that amount of water will be accounted for as part of the delivery of Metropolitan's Colorado River entitlement for the next succeeding calendar year.

Reservoir Operations

As noted previously, Reclamation owns and operates storage facilities located below Parker Dam that are used in the regulation of river flows and that also provide other benefits such as flood control protection, navigation, recreation, and power production. A description of the operation of these reservoirs follows.

Senator Wash Dam and Reservoir

Senator Wash Dam and Regulating Reservoir is located 20 miles northeast of the city of Yuma, Arizona, on the California side of the Colorado River approximately two miles upstream from Imperial Dam. This strategic off-stream water storage reservoir was constructed by Reclamation to facilitate water scheduling and to help in balancing the river flows and supply with demands. This is achieved by storing part of the Colorado River flow when excess flows are available above Imperial Dam and releasing the water in storage back to the river for downstream use when needed.

Senator Wash Reservoir was designed to have a water surface area of about 470 acres at a maximum operating elevation of 251 feet msl. At this water surface elevation, the design storage capacity is approximately 13,840 af. The reservoir has inactive (dead) storage below elevation 210 feet msl which has an estimated capacity of about 1,577 af. The design active storage is located between elevations 210 feet msl and 251 feet msl and is estimated to be about 12,259 af.

Current operational restrictions limit the use of the full storage capacity available at Senator Wash Reservoir. The operational restriction of Senator Wash Reservoir is associated with Safety of Dams concerns. Previous structural evaluation, studies of the dam, and related facilities have shown evidence of potential piping through and around the foundation of the dam (transportation of dam embankment foundation material caused by seepage that could lead to failure of the dam or dikes). There is a potential for failure of the foundation or embankment which could result from liquefaction during an earthquake. The maximum operating water surface elevation of Senator Wash Reservoir was previously restricted to 235 feet msl with temporary incursions up to 240 feet msl. However, with the recent installation of a geomembrane liner along the bottom of a portion of the reservoir, the maximum unrestricted operating water surface elevation has been raised to 240 feet msl.

Reclamation is currently undertaking additional studies and evaluations of the dikes and dam of Senator Wash Reservoir to determine what corrective actions are needed to restore the full design operating storage capacity of the reservoir. The current plan is to complete whatever corrective actions are recommended within the next 15 years in order to restore the full use of this critical water storage facility.

Imperial Dam and Reservoir

The Imperial Dam, the reservoir that forms behind Imperial Dam and the Desilting Works are situated on the Colorado River some 18 miles northeast of Yuma, Arizona. The purpose of the dam is to raise the water surface of the river flows by approximately 25 feet msl to provide controlled gravity flow of water into the All-American and Gila Gravity Main Canals. The All-American Canal system diverts water from the California side of Imperial Dam and serves IID, CVWD, the Yuma Project in Arizona and California, and the City of Yuma. The Gila Gravity Main Canal system diverts water from the Arizona side of Imperial Dam and serves the north and south Gila Valley, Yuma Mesa, and Wellton-Mohawk area. Imperial Dam is also used to regulate deliveries to Mexico. The All-American Canal Desilting Works remove most of the sediment carried by the Colorado River prior to the water entering the All-American Canal.

The flows arriving at Imperial Dam normally range from a high of about 14,400 cfs (usually occurring in late spring to summer) to a low of about 2,500 cfs. The low flow period usually occurring after heavy rainfall occurs in the area below Imperial Dam (usually November, December, and January). During these wet weather periods, the rain saturates the farm fields, and the farmers and respective water agencies adjust or cancel their water delivery orders. Mexico's water order is required to be delivered regardless of wet weather or excess rainfall conditions.

The reservoir created by Imperial Dam initially had a capacity of 83,000 af. This storage capacity was not considered a project feature and, as anticipated, the reservoir quickly filled with sediment. The reservoir capacity is now considered to be approximately 1,000 af and intermittent dredging is required to maintain the required diversion capacity at the All-American Canal and Gila Gravity Main Canal Headworks.

The normal operating range for the Imperial Reservoir is between 180 feet msl and 180.85 feet msl. However, if the amount of water arriving at Imperial Dam is less than the demands, and pulling water out of Senator Wash cannot keep the water surface elevation of Imperial Reservoir from continuing to fall, diversions at elevations below elevation 180.0 feet msl can be made to the All-American Canal or the Gila Gravity Main Canal. Under certain conditions, it may be possible to draw down Imperial Reservoir elevations as low as 178.5 feet msl.

Laguna Dam and Reservoir

Laguna Dam is located on the Colorado River some 13 miles northeast of Yuma, Arizona, and about five miles downstream from Imperial Dam. The original purpose of this dam was to divert Colorado River water to the Yuma Project area. Laguna Dam now serves as a regulating structure for Colorado River water, for regulating sluicing flows from Imperial Dam, and for downstream toe protection for Imperial Dam. The reservoir created by Laguna Dam is commonly referred to as Laguna Reservoir.

Water can be stored in Laguna Reservoir between water surface elevations 142 feet msl to 151.3 feet msl. The top of the overflow weir at Laguna Dam is at 151.3 feet msl. A small amount of additional storage can be obtained by forcing water into surcharge above the weir. The current estimate of the available storage capacity at Laguna Reservoir, between elevation 142 feet msl and 151.3 feet msl, is about 400 af.

The flows that occur below Imperial Dam and that flow into the Colorado River channel and Laguna Reservoir typically range from about 250 cfs to 350 cfs and comprise principally of return flows from the All-American desilting basins and gate leakage from the California sluiceway gates at Imperial Dam. Occasionally, sluicing flows are released to remove sediment accumulated from the desilting basins in the sluiceway channel. These flows occur two to three times per month, may range from 8,000 cfs to 12,000 cfs, and the duration may be up to 20 minutes. These flows carry the sediment to the Laguna Desilting Basin located about two miles downstream from Imperial Dam.

Flow releases from Laguna Dam typically range between 300 and 500 cfs. Occasionally, flows up to 4,000 cfs or higher may occur coincident with or following heavy rainfall.

Parker Dam and Lake Havasu

Parker Dam's primary purpose is to provide reservoir storage (Lake Havasu) from which water can be pumped into the Colorado River Aqueduct and Central Arizona Project Aqueduct. Other benefits provided by Parker Dam and Lake Havasu include flood control protection, releases for beneficial uses downstream, navigation, recreation, and power production. Lake Havasu is the southernmost major reservoir on the Lower Colorado River and it is also used to re-regulate water releases from Hoover and Davis Dams that are made to generate power at those facilities.

Reclamation collects water orders from Mexico, the All-American Canal users, the Gila Gravity Main Canal users, North Gila Canal users, various Indian Tribes, Palo Verde Irrigation District (PVID), etc. This data is compiled and sent to the BCOO River Operations Group office in Boulder City, Nevada. The BCOO River Operations Group schedulers profile hourly releases using the electric service customer's energy load profiles.

Daily releases from Parker Dam are scheduled to ensure that a specified amount of water is released to meet downstream water orders. The hourly release schedule for the dam is then structured to coordinate the maximum release through the power plant at the time of the peak usage of electricity; to the extent such release is compatible with the timing of the water deliveries and other constraints.

The water released from Parker Dam has a three-day travel time to Imperial Dam, a major diversion point for irrigation. Elevated water releases on Saturday and Sunday, when power is in less demand and revenue is less, will arrive at Imperial Dam on Tuesday and Wednesday, workdays for the growers. Conversely, low releases on Wednesday and Thursday (when power has a higher "weekday" value) will arrive at Imperial Dam on Saturday and Sunday, not typically workdays for the growers. These profiles are coordinated with Western's power schedulers in Phoenix, Arizona, and the control room operators located at Hoover Dam.

There are very minimal moment-to-moment dynamic fluctuations of the generating units. If there are changes to hourly flows, the schedule change usually begins ten minutes to the hour and is fully implemented ten minutes after the hour. These flow changes are computer controlled and the changes to the unit releases are programmed well in advance.

Table J-5 provides an example of an hourly projected release schedule used by the dam operators to schedule Parker Dam water releases and power generation. The table reflects the May 22, 2001 conditions. Each day, the current day's schedule is revised and the next day's schedule is set by BCOO River Operations Group schedulers to meet the daily required downstream water release.

Table J-5. Manual Scheduling Unit of the Parker Water Schedule (Today)—Calculated and Actual Power Generated for May 22, 2001

Hour	P1	P2	P3	P4	Forebay	Tailbay	Head	Average Calculated Flow	Generation Scheduled MWH	Generation Actual MWH
1	3	0	72	0	447.6	368.5	79.11	5.11	27	26
2	0	0	72	0	447.6	367.1	80.53	4.81	27	26
3	0	0	72	0	447.6	366.3	81.36	4.80	27	26
4	0	0	72	0	447.7	366.1	81.55	4.81	27	26
5	0	0	72	0	447.7	366.1	81.63	4.80	27	26
6	35	2	72	0	447.7	366.1	81.61	6.54	33	35
7	72	72	72	4	447.7	367.2	80.50	13.51	78	78
8	72	73	72	73	447.8	369.3	78.47	18.44	102	100
9	72	72	72	72	447.8	371.0	76.85	18.46	103	99
10	72	72	72	73	447.8	371.4	76.41	18.52	103	99
11	72	71	72	72	447.8	371.5	76.29	18.36	103	98
12	71	71	71	71	447.8	371.5	76.29	18.22	103	97
13	71	71	71	71	447.8	371.5	76.29	18.23	103	97
14	71	71	71	71	447.7	371.5	76.27	18.24	103	97
15	72	72	72	72	447.7	371.8	75.93	18.20	103	0
16	72	72	72	72	447.7	371.8	75.95	18.20	103	0
17	72	72	72	72	447.7	371.8	75.95	18.20	103	0
18	72	72	72	72	447.7	371.8	75.95	18.20	103	0
19	72	72	72	72	447.7	371.8	75.95	18.20	103	0
20	72	72	72	72	447.7	371.8	75.95	18.20	103	0
21	72	72	72	0	447.7	370.3	77.39	13.95	79	0
22	72	72	72	0	447.7	370.4	77.32	13.94	79	0
23	72	0	72	0	447.7	368.6	79.16	9.46	54	0
24	-1	0	72	0	447.7	366.2	81.56	4.84	27	0
Average Release Total								13.51		1886
Scheduled Average Release									13.50	
Schedule Error								-0.01		

Scheduling Terminology:

Gate position of = % of Gate Opened

P1 = Parker Generator # 1

P2 = Parker Generator # 2

P3 = Parker Generator # 3

P4 = Parker Generator # 4

Forebay (feet) = Elevation of the lake formed by the Dam measured in feet msl

Tailbay (feet) = The elevation of the released water level from the Dam measured in feet msl

Head (feet) = The difference between Forebay and Tailbay

Average Calculated Flow = Calculated flow thru the generating units with the given gate positions for the hour

Generation Actual = Actual generation for the hour in megawatts per hour (MWH)

Davis Dam and Lake Mohave

Davis Dam's primary purpose is to re-regulate Hoover Dam releases and aide in the delivery of water supplies to downstream U.S. entitlement holders and to Mexico. Other benefits provided by Davis Dam and Lake Mohave include flood control protection, navigation, recreation, and power production.

Water schedulers collect and compile water delivery orders from CAP, Metropolitan, and other Colorado River entitlement holders that divert water between Davis Dam and Parker Dam. The hourly release schedule for the Davis Dam is then integrated with the Parker Dam scheduled water releases and other objectives to coordinate the maximum release through the power facilities at the time of the peak usage of electricity; to the extent such release is compatible with the timing of the water deliveries and other constraints.

The maximum instantaneous release for Davis Dam is 28,000 cfs and the minimum instantaneous release that can be expected under other than normal operating conditions is about 1,000 cfs. The minimum amount represents approximately one half of the release needed to turn one of the Davis Dam Power Plant's turbines. Such low flows are usually associated with downstream flooding, construction, search and rescue, or other emergency conditions.

The Davis Dam generating units are capable of providing moment-to-moment dynamic control. However, there is minimal use of this dynamic capability. If there are changes to hourly flows, the schedule change usually begins ten minutes to the hour and is fully implemented ten minutes after the hour. These flow changes are computer controlled and the changes to the unit releases are programmed well in advance.

The minimum water surface elevation of Lake Mohave without resetting the intake stops is at about elevation 630 feet msl. The maximum elevation is 646.5 feet msl, where wave action begins to leak into the Dam's inspection gallery. The daily releases are coordinated such that the end of month target water surface elevations are achieved (see Section J.4.3.3).

The razorback sucker backcove rearing program that began in 1994 can also limit the drawdown to no more than two feet in a ten-day period during the razorback sucker spawning season (see Figure J-4). Further, the program also requires that the Lake Mohave water surface elevation be maintained above elevation 640 feet msl between the period between March 15 and June 15 to provide sufficient depth for the backcove rearing areas. These limitations require closer coordination of Lake Mohave with that of Lake Havasu as well as adjustment to the Hoover Dam hourly water release and energy production schedules. The operators take all these factors into account in the management of the Lake Mohave daily water surface levels.

Hoover Dam and Lake Mead

Hoover Dam's authorized purposes are first; river regulation, improvement of navigation, and flood control; second, delivery of stored water for irrigation and other domestic uses;

and third, power generation. However, unlike Davis and Parker Dams, the water releases from Hoover Dam are not restricted to a specified daily release. Prior to the first day of the month, a monthly energy target is determined based on the monthly water release requirements. The monthly power generation schedule is sent to Western, where it is converted into an estimated weekly power generation schedule. As the month progresses, the energy target can be adjusted in coordination with Western.

The Hoover Dam hydroelectric power generators are operated using Automatic Generation Control (AGC). This control system automates the water releases from Hoover Dam in a manner that follows the power system's actual dynamic demands on a moment-to-moment (four-second interval) basis. The purposed of the AGC system and this manner of operation is to optimize the energy production consistent with the monthly water release schedules and not daily water release schedules such as at Davis and Parker Dams. To the degree that storage capacity is available, Lake Mohave is used to store flows released from Hoover Dam for power generation purposes until water is required to be released to meet scheduled water deliveries to downstream water users in the United States and Mexico. This is possible because of the close proximity of Lake Mohave to Hoover Dam and the storage capacity usually available at Lake Mohave.

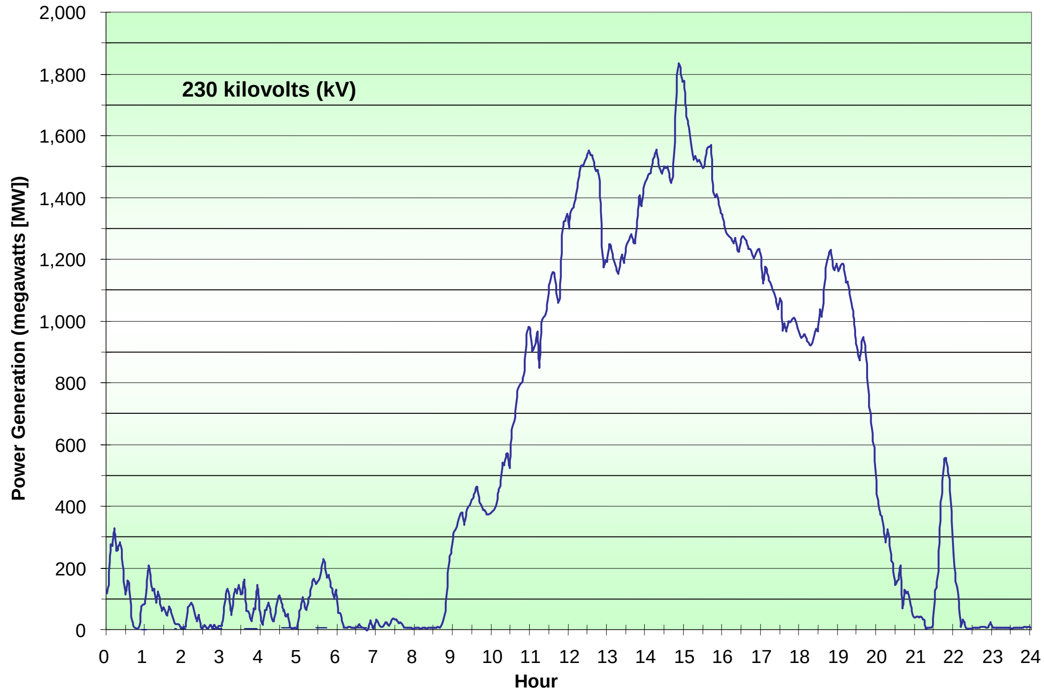
The Western Electricity Coordinating Council (WECC) operates according to national standards established by the North American Electric Reliability Council for power system operation. Reclamation and Western are fully participatory members of the WECC and follow the mandatory industry standards.

The daily water releases from Hoover Dam that are made to meet downstream water demands can range between 800 cfs to 25,400 cfs. The minimum water release values typically coincide with high flood events on the Bill Williams and/or Gila rivers.

The operating water level of Lake Mead does not fluctuate by a significant amount on a daily basis due to the large storage capacity of Lake Mead. Further, the Lake Mead water surface elevations are not operated on a monthly target water surface elevation, like Lakes Mohave and Havasu. Instead, Reclamation has the ability to use the full active storage capacity of Lake Mead to regulate river flows and manage the water supplies and downstream water demands. The Lake Mead active storage capacity is situated between water surface elevations 895 feet msl (top of dead storage) and 1,221 feet msl (top of raised spillway gates). However, under the flood control operations, the maximum water surface elevation can be raised to 1,229 feet msl (maximum pool elevation). Flood control operating criteria define Lake Mead's uppermost 1.5 maf of storage capacity, between elevations 1,219.6 and 1,229 feet msl, as exclusively for flood control.

Figure J-9 provides an example of the dynamic energy changes that occur within a day. The actual flow releases follow these patterns. However, it needs to be noted that even though the figure shows power generation approaching zero production at different times of the day, this does not mean that the water releases from Hoover Dam are also reduced to zero. On any give day throughout the year, the typical minimum water releases from Hoover Dam on daily basis can range between 1,000 cfs to 2,000 cfs.

Figure J-9
Typical Dynamic Power Generation at Hoover Dam (230 kV bus)
(Measured September 20, 1999)



J.5 Historical LCR Operating Conditions

The overview of historical LCR operating conditions presented in this section is based on normal (non-flood control) years between 1980 and 2001. During flood control operating conditions, the operation of the reservoirs and river system is governed by the flood control operating criteria as discussed in Section J.4.3.2. The flood control operating criteria are not expected to change as a result of the actions being considered. Therefore, this appendix strictly focuses on the normal operating conditions that may be affected by the actions being considered and described in the LCR MSCP BA.

The normal and flood control years for the historical period considered in this section are presented in Table J-6.

Table J-6. Normal Flow and Flood Control Years

Year	Normal	Flood Control
1980		X
1981		X
1982	X	
1983		X
1984		X
1985	X	
1986		X
1987		X
1988		X
1989	X	
1990	X	
1991	X	
1992	X	
1993	X	
1994	X	
1995	X	
1996	X	
1997		X
1998		X
1999		X
2000	X	
2001	X	
2002	X	

It is important that the reader become familiar with the terminology used in this section to describe flow, releases, river stage, and reservoir water surface elevations, at a specific point in time or over a prescribed period.

A list of the key terminology and respective definitions follows:

Term	**Definition**
Instantaneous	Value at a particular instant in time.
Mean Hourly	Average of many instantaneous values for a particular one-hour period.
Mean Daily	Average of the 24-hourly values, or the average of the instantaneous values that occur over a 24-hour period.
Mean Monthly	Average of the daily values that occur for a particular month.
Mean Annual	Average of the 12 monthly values that occur for a particular year.
Hourly Value	The instantaneous value that is recorded at the top of the hour.
Midnight Value	The instantaneous value that is recorded at midnight of a particular day.

Term	Definition
End of Month	The instantaneous value that is recorded at midnight of the last day of a particular month.
End of Year	The instantaneous value that is recorded at midnight of the last day of a particular year.

J.5.1 Historical Hoover Dam/Lake Mead Operations

Figure J-10 shows the mean daily releases for Hoover Dam for all years, 1980 through 2001. The maximum non-flood year mean daily release is shown to be 25,400 cfs during March 1994 and is a result of the Hoover turbine uprating in 1993 making higher releases possible. The increase in daily release due to the uprating of the turbines appears to have increased the maximum mean daily release by about 3,000 cfs. The minimum mean daily release of 800 cfs occurred during January 1993 and coincided with the high flow events on the Bill Williams River and Gila River and reflect Reclamation's efforts to manage the flood flows.

Figure J-10
Historical Hoover Dam Releases

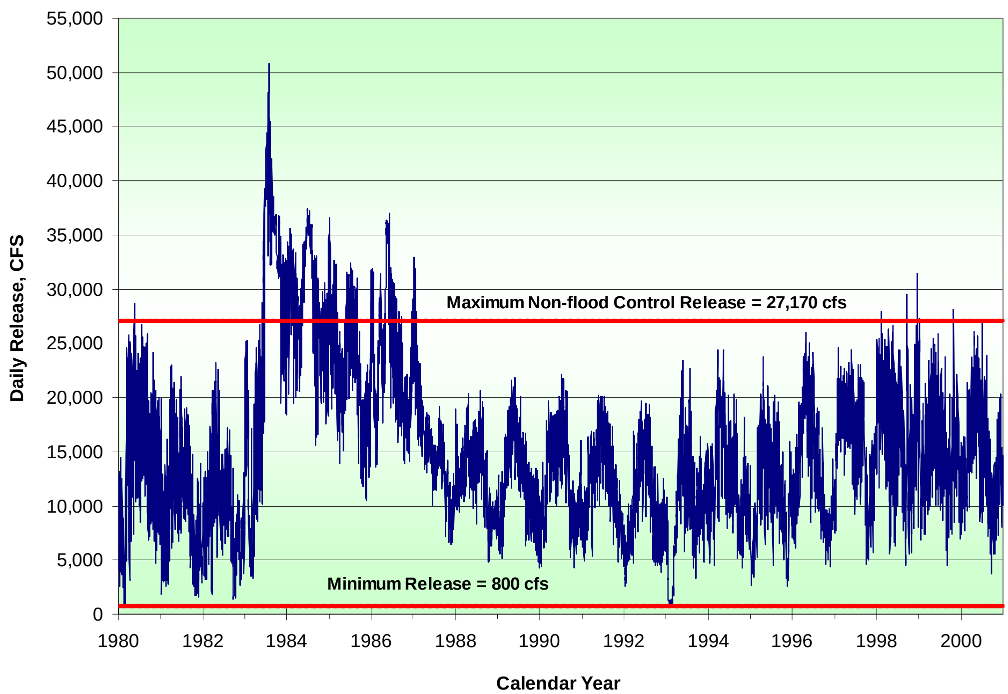


Figure J-11 shows the ranking of the 4,745 non-flood control year mean daily releases (365 days times 13 years) that were presented in Figure J-10. For example, 40 percent of the daily releases were less than 12,000 cfs.

Figure J-11
Hoover Daily Flow Duration

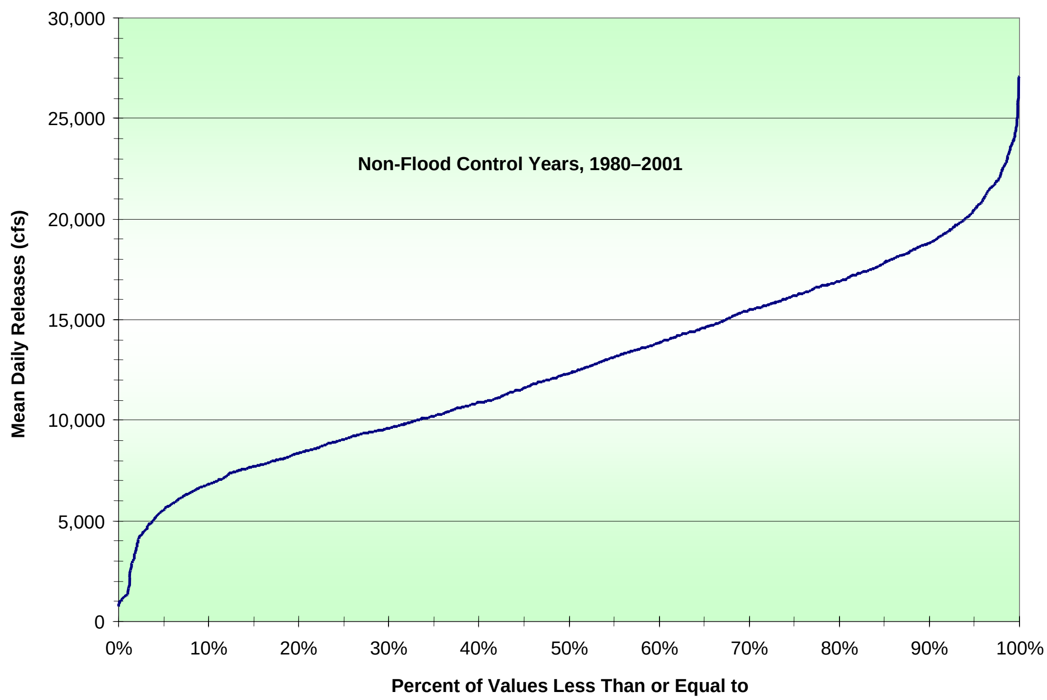


Figure J-12 shows the average, maximum, and minimum mean daily Hoover Dam releases in each month for the 13 non-flood control years. For example, January average daily release is 7,500 cfs. The maximum mean daily release is 15,500 cfs and the minimum is 800 cfs. A visual inspection of the average values shows how releases change during the year to meet downstream demands. Also noted is the highest possible instantaneous power release for Hoover Dam of 49,000 cfs. The minimum instantaneous release that can be expected under other than normal operating conditions is about 500 cfs or equal to the release for one of the seventeen power plant turbines. Such low release conditions are associated with downstream flooding, construction, search and rescue, or for other emergency conditions.

Figure J-12
Hoover Daily Mean Release Range

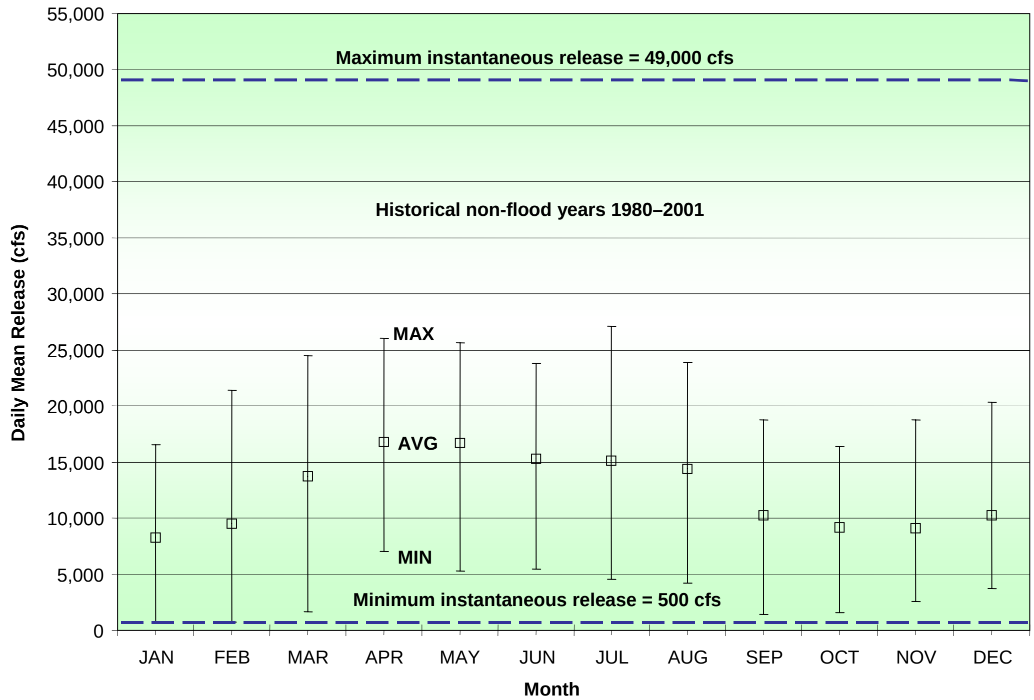
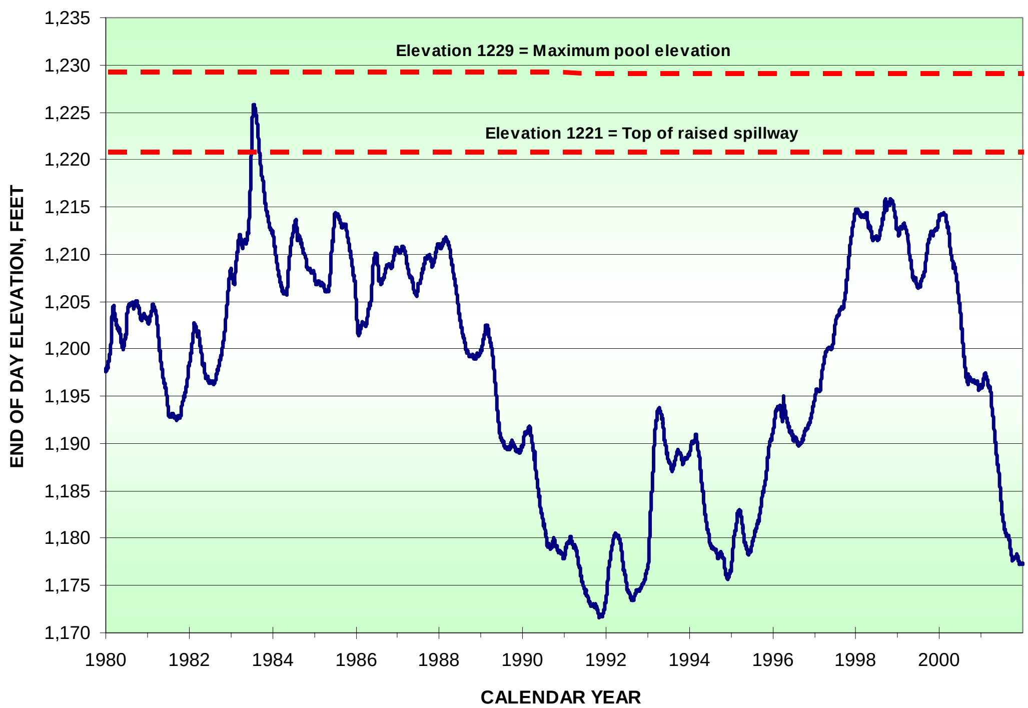


Figure J-13 shows Lake Mead midnight elevations for years 1980 through 2001. The period between years 1989 to 1991 show how the Lake Mead water levels decline when minimum objective releases from Glen Canyon Dam are made and the demands in Lower Basin are high, due to low rainfall conditions. Conversely, the Lake Mead water levels increased in 1993 when flooding occurred from the Gila River and Lake Mead releases were curtailed to prevent further damage. In addition, during 1993, the Lower Basin water demands were generally lower than normal as a result of the heavy rainfall, and this helped to keep more water in storage at Lake Mead.

Figure J-13
Lake Mead Daily Pool Elevation



In 1995, there was again an increase in Lake Mead water surface elevations that resulted from additional flows from the Gila River and equalization releases from Glen Canyon Dam. The annual volume of water released from Glen Canyon Dam is made according to the provisions of the Long Range Operating Criteria (LROC). Under these provisions, annual releases from Lake Powell greater than the minimum occur if Upper Basin storage is greater than the storage required by section 602(a) of the Colorado River Basin Project Act, and if the storage in Lake Powell is greater than the storage in Lake Mead, or in the case of spill avoidance.

Figure J-14 shows the average, minimum, and maximum monthly Lake Mead midnight elevations for the non-flood control years between 1980 and 2001. These are the water surface elevations that are recorded at midnight of the last day of the month. Over this period, the highest monthly average occurred in March and the lowest monthly average occurred in August.

Figure J-14
Lake Mead Daily Elevation Range

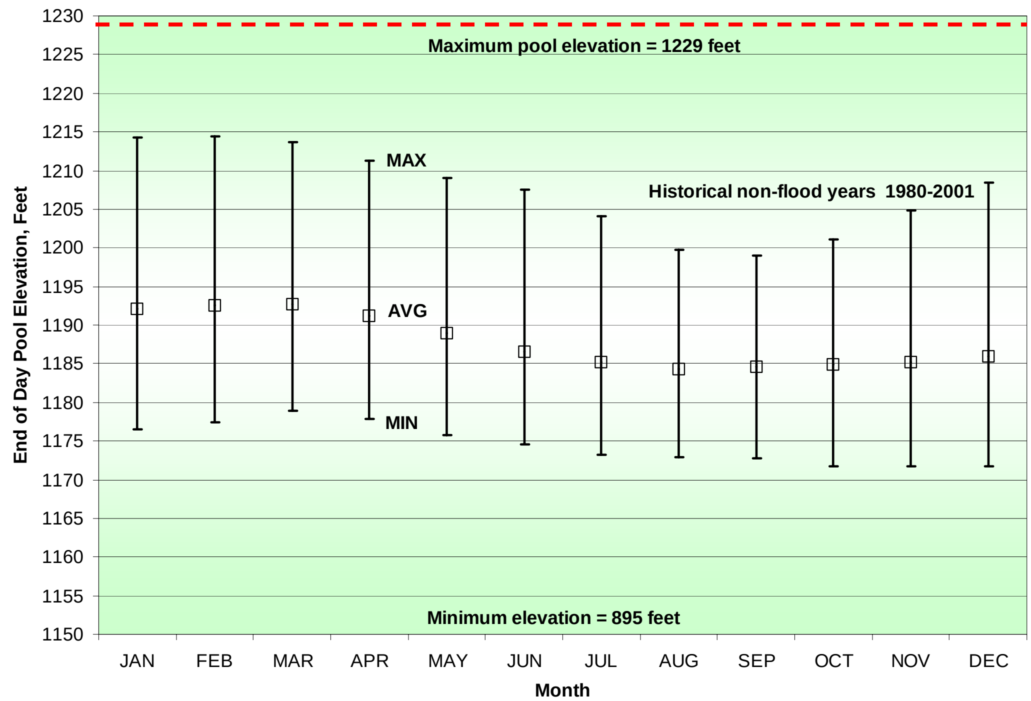
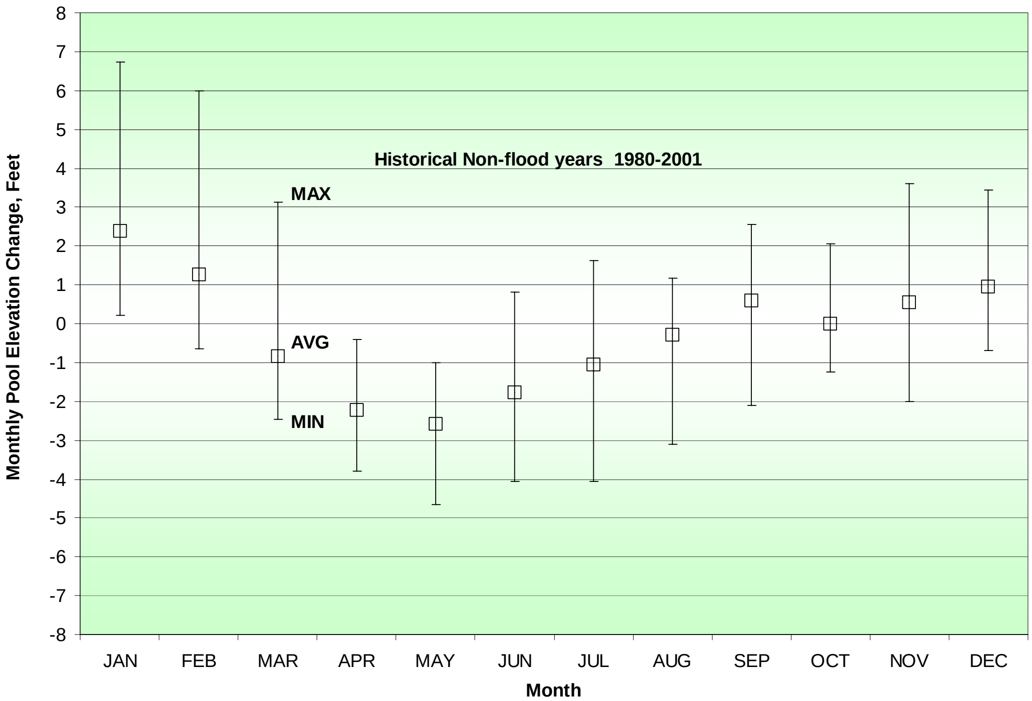


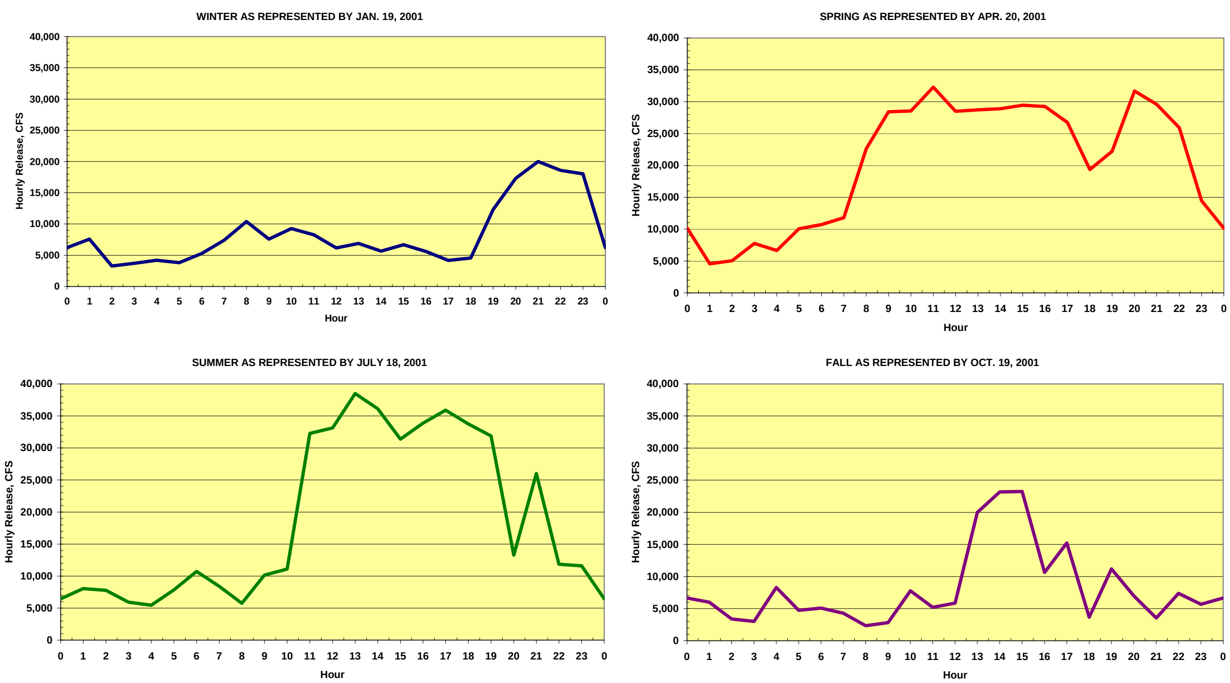
Figure J-15 provides information on the monthly change in Lake Mead water surface elevations. The largest monthly elevation increase generally occurs in January and averages about +2.5 feet msl. The largest elevation monthly decrease generally occurs in May and averages about –2.5 feet msl.

Figure J-15
Lake Mead Monthly Pool Elevation Change



The typical hourly release patterns from Hoover Dam within a day also vary by season due to varying energy demands during each season. Figure J-16 shows the Hoover Dam typical hourly release pattern for a representative day in each of the four seasons. Hoover Dam's water releases fluctuate more than do the releases from Davis and Parker Dams because it is used to respond to the rapid power system fluctuations.

Figures J-16
Hoover Dam Hourly Releases for Typical Seasonal Flow Release Patterns



J.5.2 Historical Davis Dam/Lake Mohave Operations

Figure J-17 shows the mean daily releases for Davis Dam for the period between 1980 through 2001. The maximum non-flood year mean daily release is shown to be 22,000 cfs during April 1989 and resulted from high downstream water demands. The minimum mean daily release of 1,600 cfs occurred during January and February of 1993 and reflects Reclamation's actions to manage the high flows on the Bill Williams River and Gila River.

Figure J-17
Davis Dam Daily Release

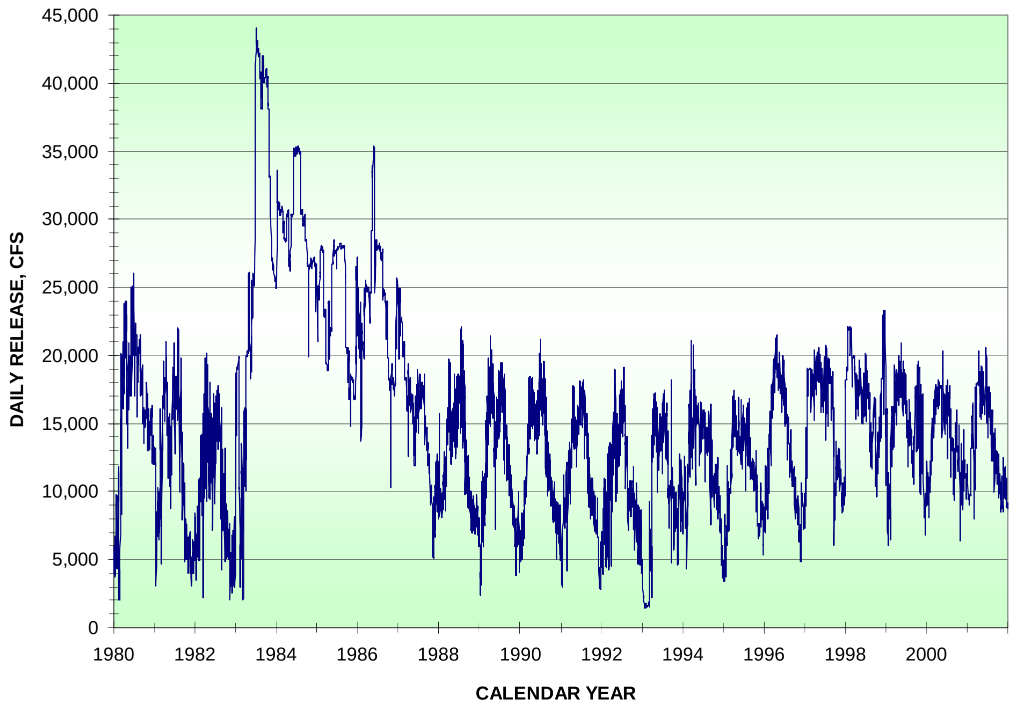


Figure J-18 presents the ranking of the 4,745 (365 days per year times 13 years) mean daily releases for the non-flood control years. For example, the ranking of the values indicate that approximately 40 percent of the mean daily releases are less than 11,000 cfs.

Figure J-18
Davis Dam Mean Daily Flow Release

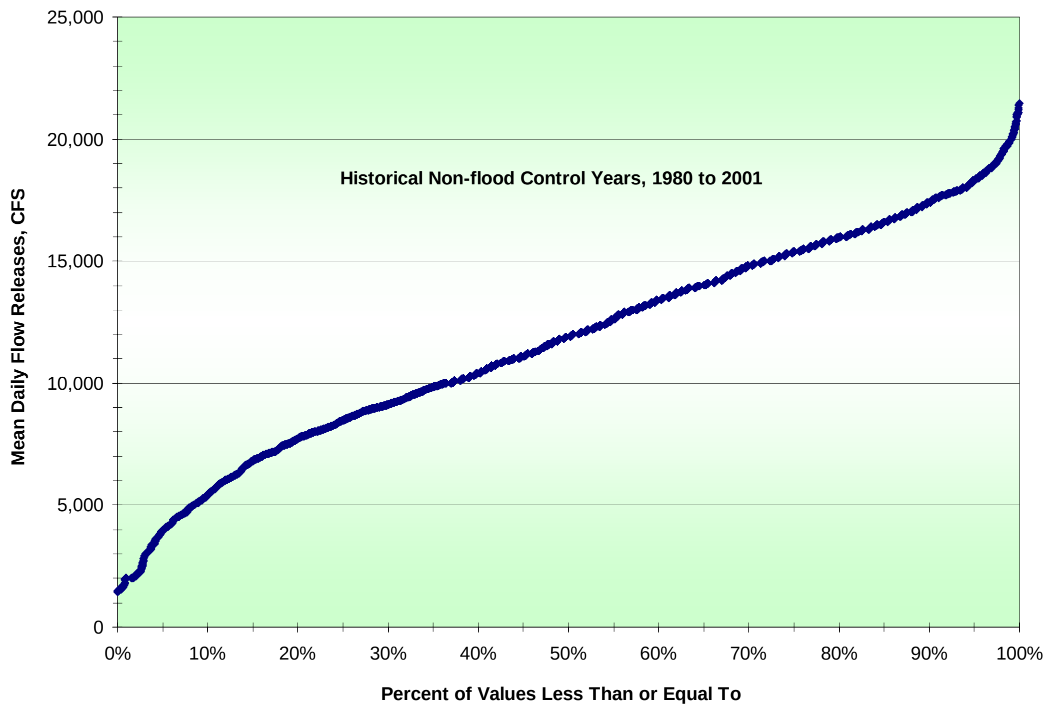


Figure J-19 presents the average, minimum, and maximum mean daily Davis Dam releases for the 13 non-flood control years. A visual inspection of the averages shows how flow releases change during the year to meet the downstream water demands. Also noted is the maximum instantaneous release for Davis Dam of 28,000 cfs. The minimum instantaneous release that can be expected under other than normal operating conditions is about 1000 cfs. This amount represents approximately one-half of the release needed to turn one of the Davis Dam Power Plant's turbines. Such low flows are usually associated with downstream flooding, construction, search and rescue, or other emergency conditions.

Figure J-19
Davis Daily Mean Release Range

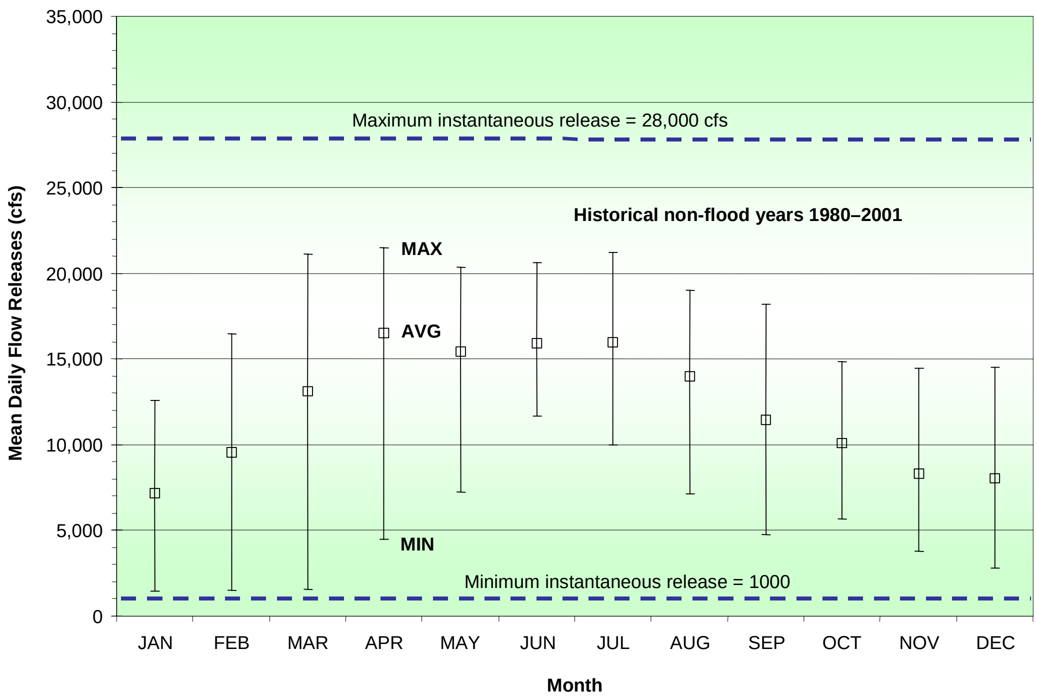


Figure J-20 shows the Lake Mohave daily water surface elevations. These elevations comprise the elevations recorded at midnight of each day during the period. The data shows that Lake Mohave generally reaches its maximum elevation in the spring and its minimum elevation in the fall. Reclamation generally lowers the lake level in the fall to provide flood control storage space for runoff that results from large storms coming up river from Baja California, Mexico. The actual water surface elevations will sometimes differ from the target elevations (Figure J-4) with the regulation of Hoover Dam releases and the balancing of arriving flows with downstream water demands.

Figure J-20
Lake Mohave Daily Elevation

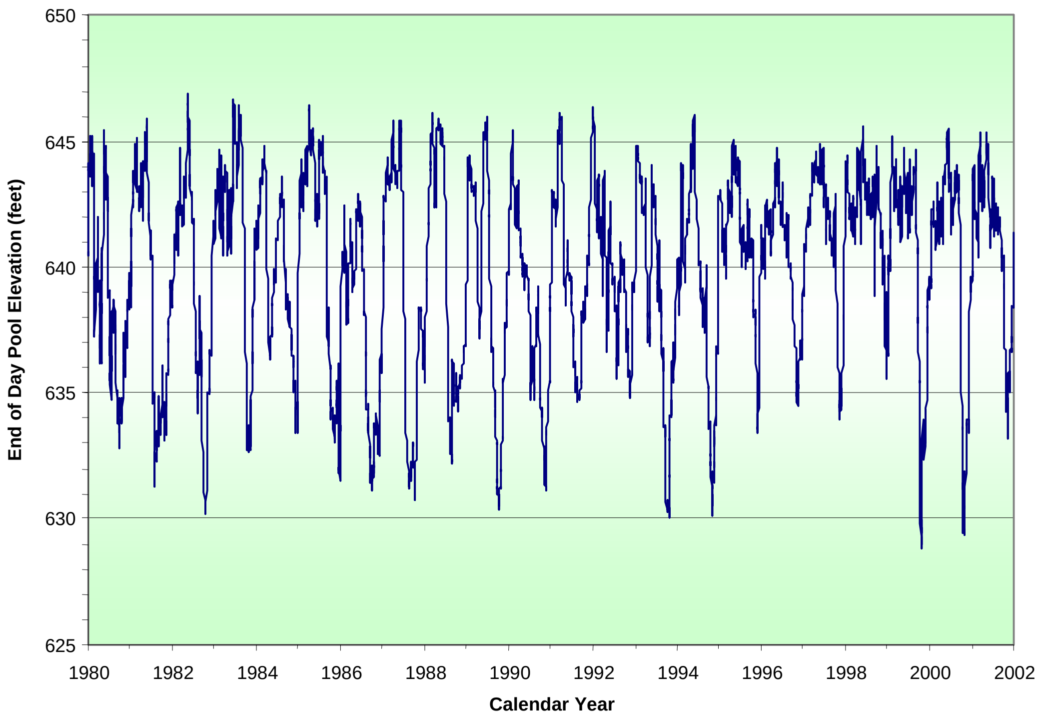


Figure J-21 shows the average, maximum, and minimum monthly water surface elevations of Lake Mohave (elevations measured at midnight on last day of month) for the non-flood control years. The maximum average occurs in February and the minimum average occurs in October/November. Also noted on Figure J-21 are the operational minimum and maximum elevations.

Figure J-21
Lake Mohave Daily Pool Elevation Range

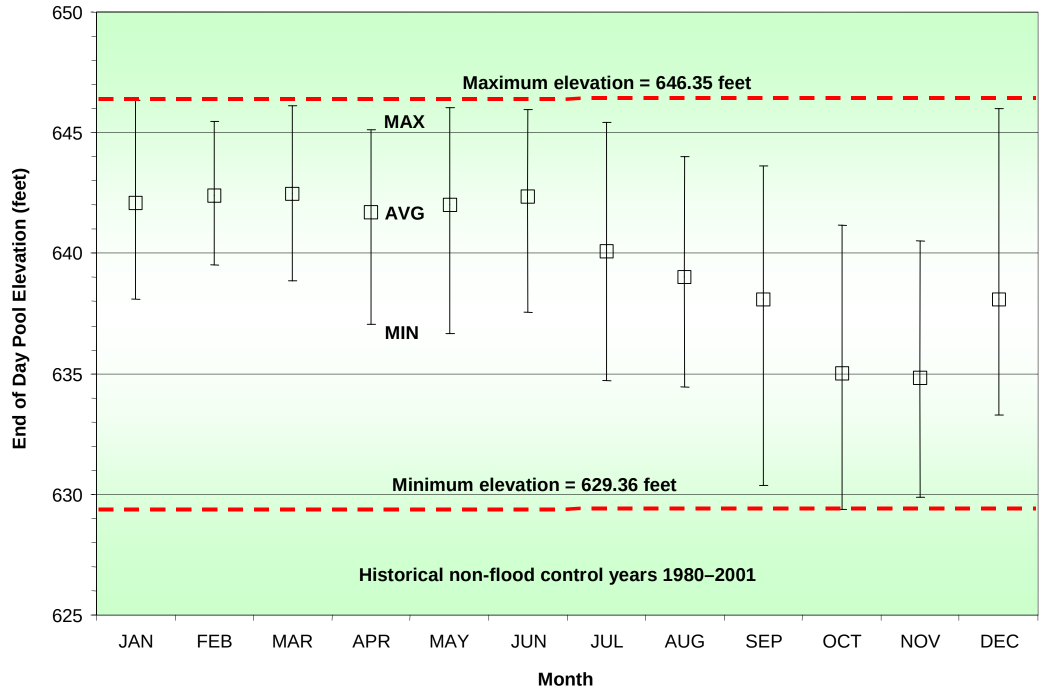
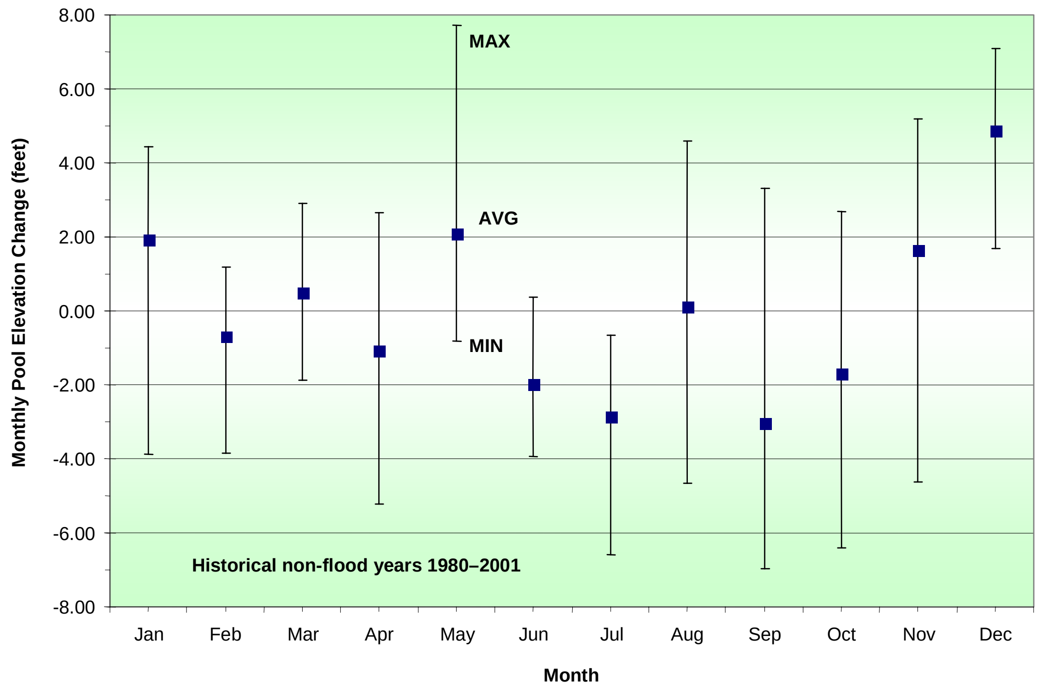


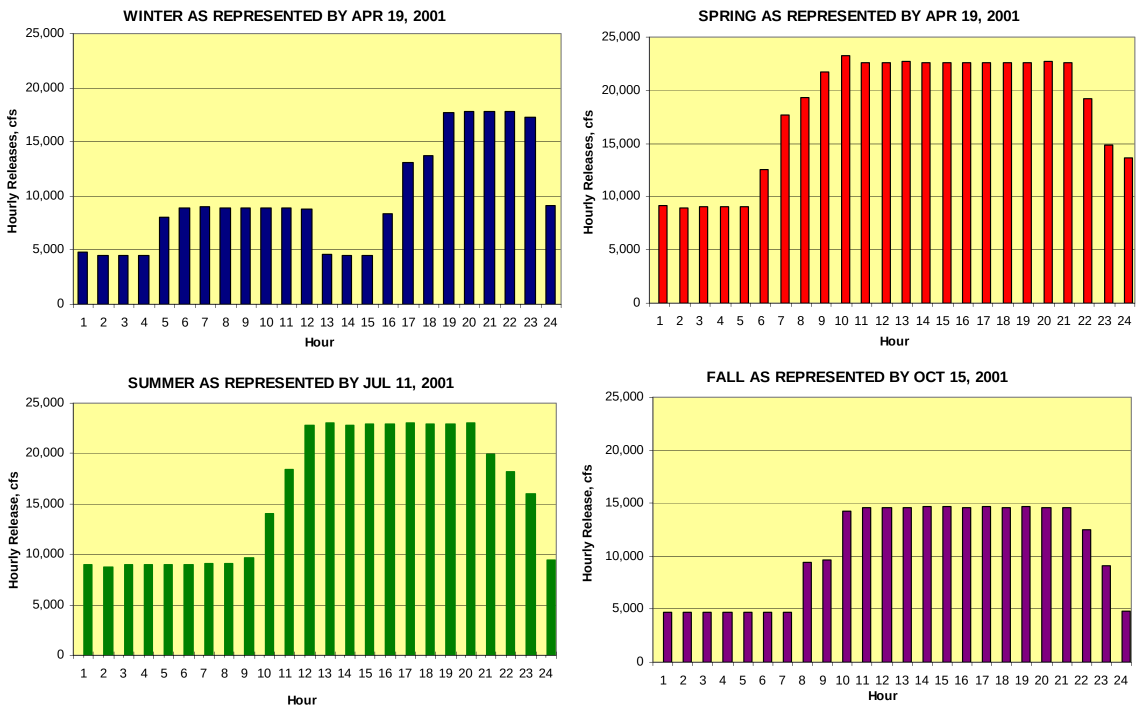
Figure J-22 provides information on the monthly change in Lake Mohave water surface elevations. This figure shows that the highest monthly average water level change generally occurs during the month of December and the lowest generally occur during the month of September.

Figure J-22
Lake Mohave Monthly Elevation Change



The Davis Dam typical hourly release patterns within a day also vary by season due to varying energy demands during each season. Figure J-23 shows the Davis Dam typical hourly release pattern, for a representative day in each of the four seasons.

Figure J-23
Davis Dam Hourly Releases for Typical Seasonal Flow Release Patterns



J.5.3 Historical Parker Dam/Lake Havasu Operations

Figure J-24 presents the mean daily releases for Parker Dam for the period between 1980 through 2001. The maximum non-flood year mean daily release is 16,800 cfs and occurred during April 1989. The minimum mean daily release is 30 cfs and occurred during January 1995. During this time, the releases were reduced to these levels to enable the Bureau of Indian Affairs to drain Lake Moovalya (the reservoir impounded by Headgate Rock Dam, downstream of Parker Dam) and perform maintenance of the Colorado River Indian Tribes diversion canal. Lake Moovalya and Headgate Rock Dam are operated by the BIA and these types of maintenance activities are closely coordinated with Reclamation (see Section 2.5.3.5 of the LCR MSCP BA).

Figure J-24
Parker Dam Mean Daily Releases

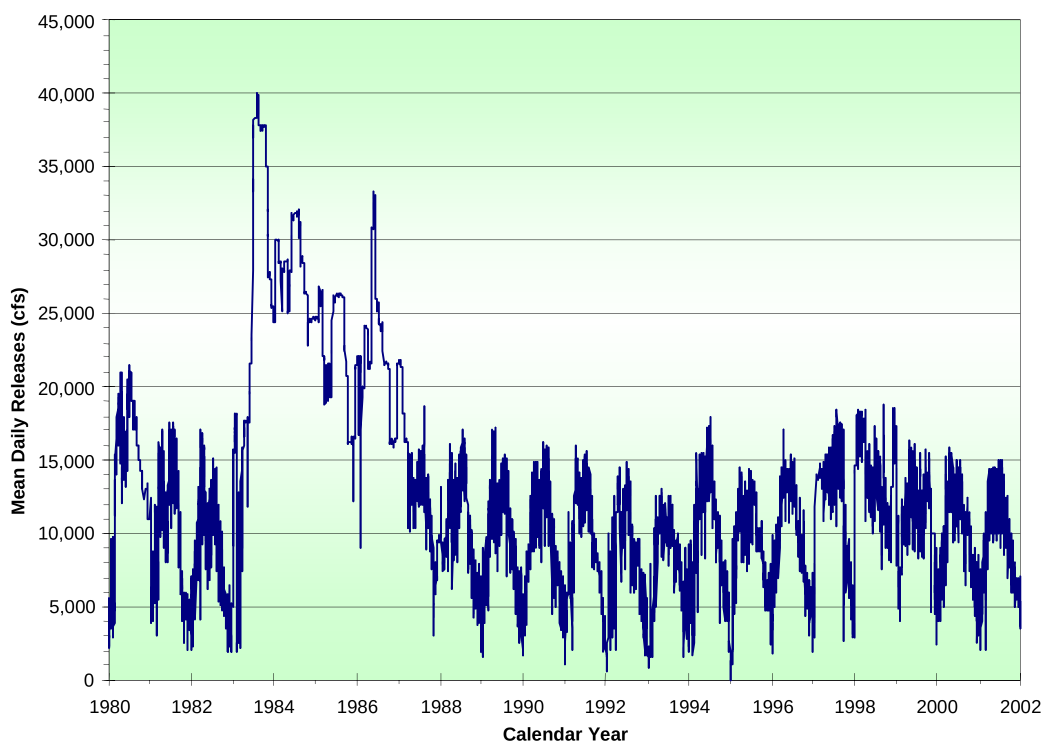


Figure J-25 presents the ranking of the mean daily releases for the non-flood control years. For example, 40 percent of the daily releases were less than 8,200 cfs.

Figure J-25
Parker Daily Flow Duration

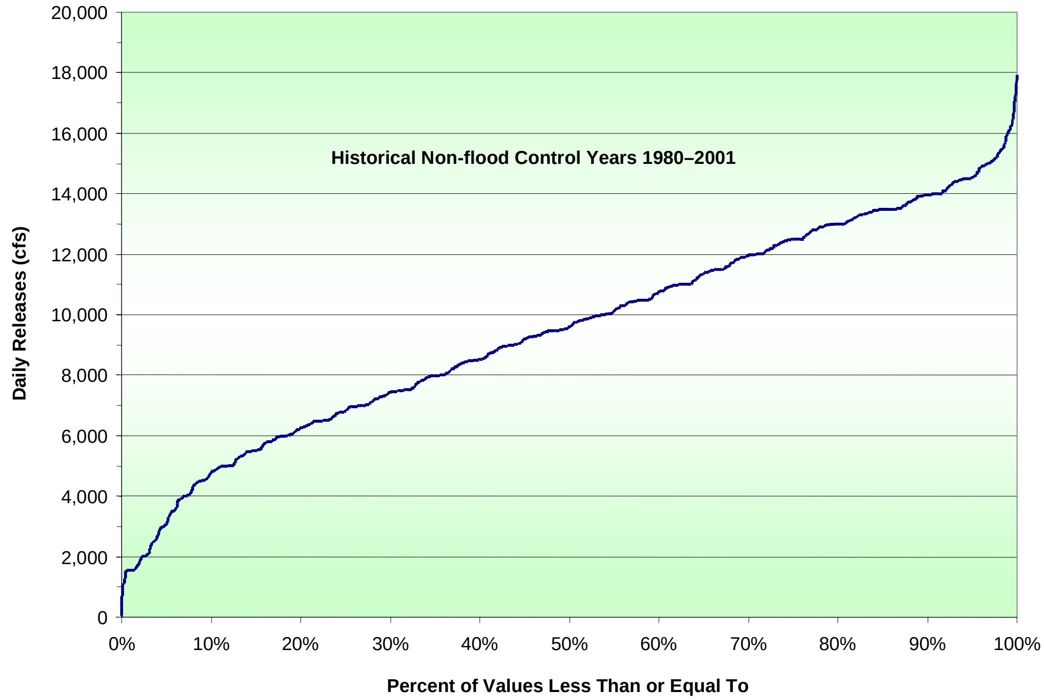
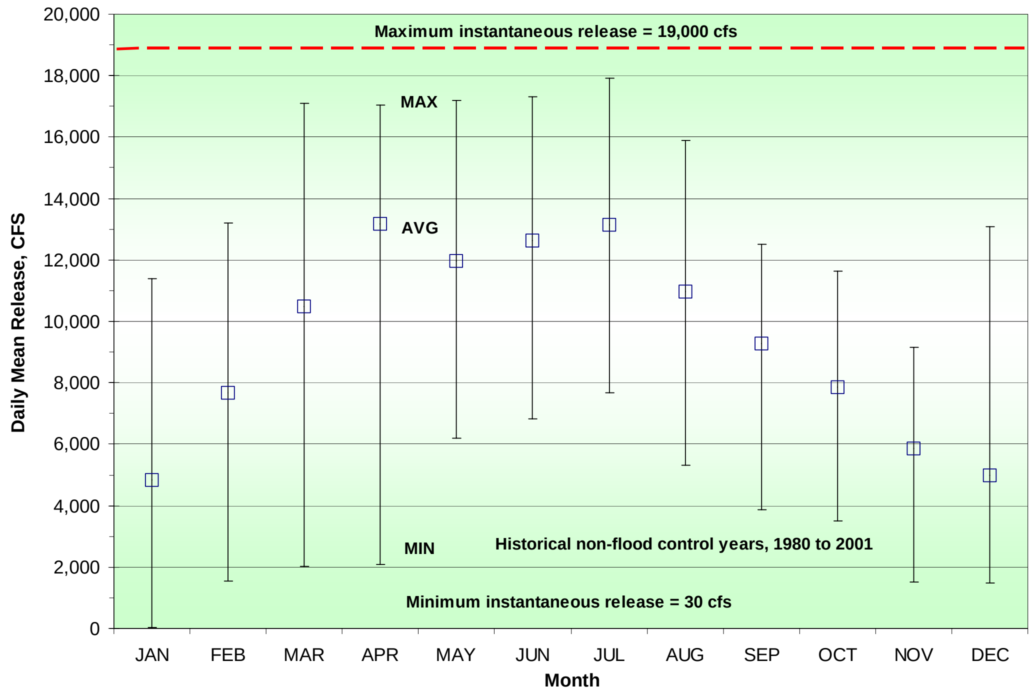


Figure J-26 shows the average, maximum, and minimum mean daily Parker release in each month within the 13 non-flood control years. The maximum January release is approximately 11,500 cfs and the minimum is 30 cfs.

Figure J-26
Parker Daily Mean Release Range



The figure provides a good visual of how the mean daily releases, and corresponding water demands, change from month to month. The maximum instantaneous releases for Parker Dam have historically been kept below the dam's maximum 19,000 cfs normal release rating. As previously noted, the minimum instantaneous release that has been recorded is about 30 cfs.

Figure J-27 presents the historical Lake Havasu daily water surface elevations for the period between 1980 through 2001. These elevations comprise the elevations recorded at midnight of each day during the period. The data shows that Lake Havasu generally reaches its maximum elevation in the spring and its minimum elevation in the winter. Reclamation generally lowers the lake level during the winter months to provide flood control storage space for runoff that results from large storms coming up river from Baja California, Mexico. The actual water surface elevations will sometimes differ from the target elevations (Figure J-5) with the regulation of Hoover Dam and Parker Dam releases and the balancing of arriving flows with downstream water demands.

Figure J-27
Lake Havasu Daily Elevation

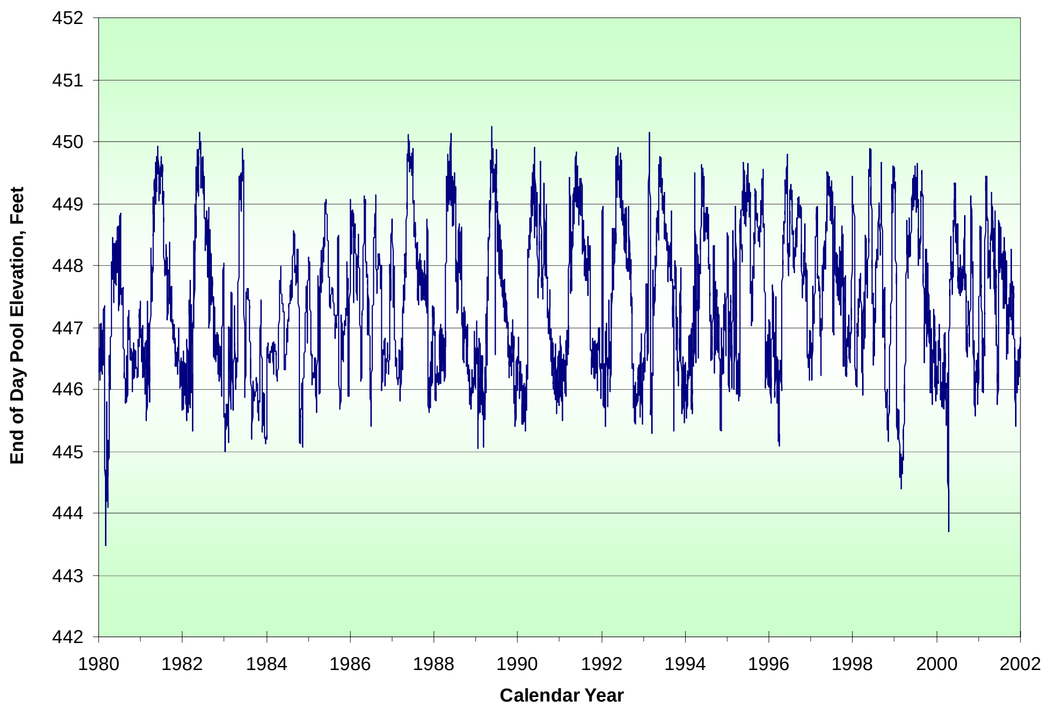


Figure J-28 presents the average, maximum, and minimum monthly water surface elevations of Lake Havasu (elevations measured at midnight on last day of month) for the non-flood control years. The maximum average of approximately 448.7 feet msl occurs in May and the minimum average of about 446.0 feet msl occurs in February. The minimum target elevation for marina operators is 445.8 feet msl. Reclamation attempts to accommodate this minimum target elevation when other higher priority uses are not compromised. The maximum Lake Havasu water surface elevation is 450.5 feet msl

Figure J-28
Lake Havasu Daily Range of Pool Elevations

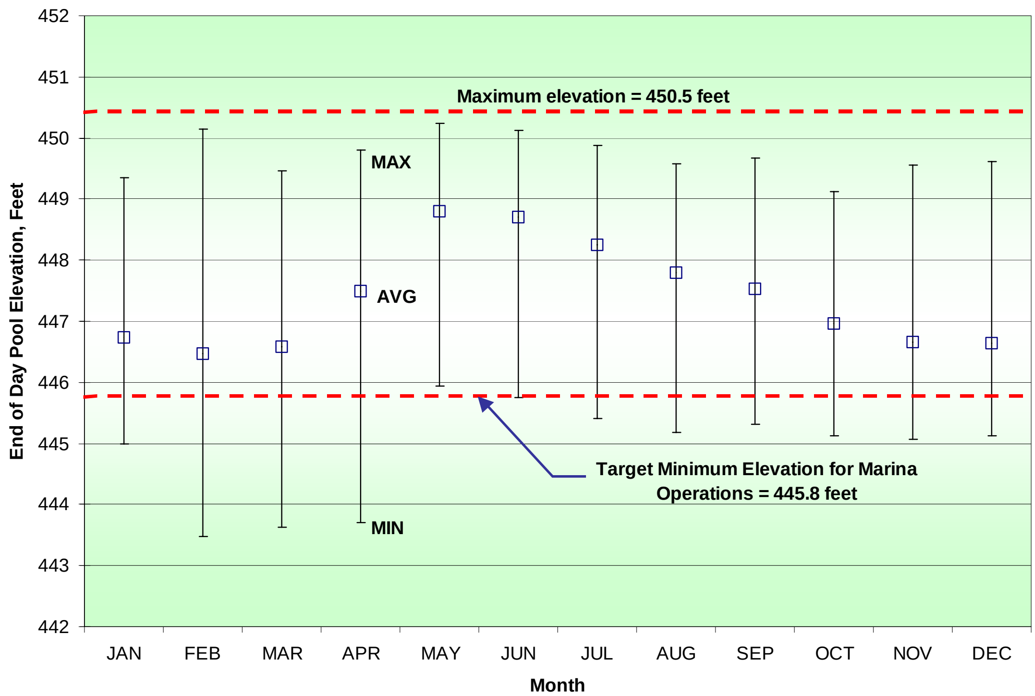
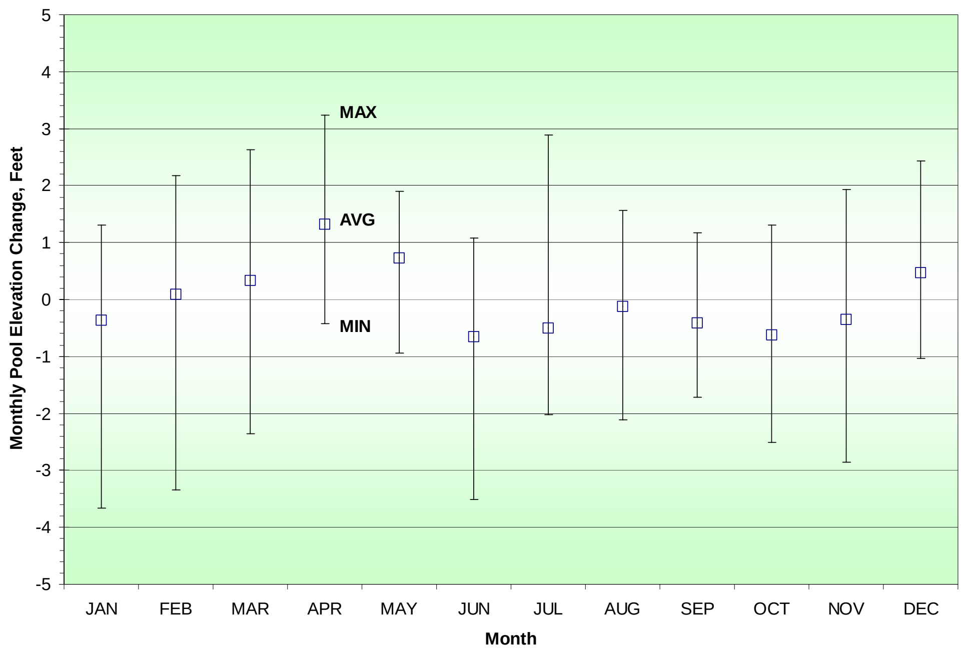


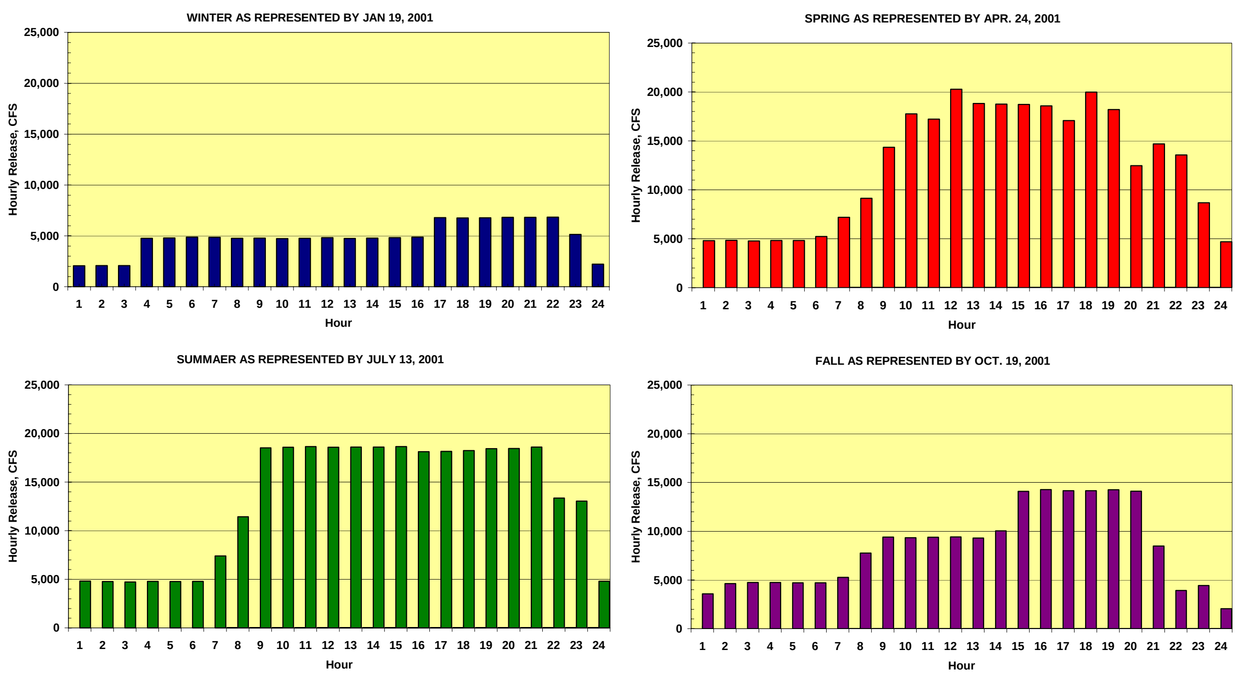
Figure J-29 provides information on the monthly change in Lake Havasu water surface elevations. The largest average monthly elevation increase occurs in April and averaged about +1.3 feet msl. The largest average monthly elevation decrease occurs in June and averages about –0.7 feet msl.

Figure J-29
Lake Havasu Monthly Elevation Change



The typical Parker Dam hourly release patterns within a day also vary by season due primarily to varying energy demands during each season. Figure J-30 shows the Parker Dam typical hourly release pattern for a representative day in each of the four seasons. The curves show a slightly flatter water release pattern for Parker Dam, as compared to that of Hoover and Davis Dams, due to the water delivery requirements below Parker Dam.

Figures J-30
Parker Dam Hourly Releases for Typical Seasonal Flow Release Patterns



J.6 Evaluation of the Hydrologic Impacts of Future Flow-Related Actions

This section evaluates the potential impacts to the LCR system that may result from ongoing and future flow-related actions. As discussed in Section J.4, the LCR system is operated to maintain specified elevations for Lake Mohave and Lake Havasu for each month of the year. Consequently, the water levels of those lakes would not be affected by the future flow-related actions. The reservoir analysis presented in this section is, therefore, focused on the effects of Lake Mead water levels only (Reach 1).

This appendix also analyzes the potential effects of future flow-related activities on Reaches 3–5. As discussed in the introduction (Section J.3), Reaches 2 and 6 would be unaffected by these actions. Potential effects on flows in Reach 7 are described in Appendix L.

Several ongoing and future flow-related actions are listed below in Section J.6.1 and described in Chapter 2 of the LCR MSCP BA and Chapter 2 of the LCR MSCP HCP. For this analysis, future flow-related actions that might affect Lake Mead water levels and the Reaches 3–5 include:

- Specific surplus and shortage guidelines, and
- Changes in storage and delivery of state entitlement waters (essentially changes in the points of delivery).

J.6.1 Potential Impacts to Lake Mead

To determine the potential effects of the actions being considered in this evaluation, computerized hydrologic modeling of the Colorado River system was conducted. Modeling enables us to develop projections of potential future Colorado River system conditions (i.e., reservoir surface elevations, river flows, salinity, etc.), given various assumptions with regard to future actions. Unfortunately, future system conditions are most sensitive to the future hydrologic inflows, which are highly uncertain. This uncertainty is dealt with in two ways: 1) the model is run multiple times, using different assumptions of hydrologic inflows, allowing a probability-based analysis of the future state of the system, and 2) the modeling results are used for a relative comparison of potential future conditions under the different operating scenarios of interest. For this analysis, two operating scenarios were analyzed: Baseline and the Action Alternative[3]. These two scenarios are described in Section J.6.1.3.

J.6.1.1 Overview of the Model

Future reservoir conditions for each scenario (Baseline and Action Alternative) were simulated using a computerized model. The model framework used for this process is the commercial river modeling software called RiverWare (Zagona et al. 2001). RiverWare was developed by the University of Colorado in cooperation with Reclamation and the Tennessee Valley Authority. RiverWare was configured to simulate the Colorado River System and its operation and integrates the Colorado River Simulation System (CRSS) model that was developed by Reclamation in the 1970s. River operation parameters modeled by CRSS on a monthly basis include the water entering the river system, storage in system reservoirs, releases from storage, river flows, and the water demands of and deliveries to the Basin States and Mexico. The water supply used by the model consists of the natural inflow in the river system over the 85-year period from 1906 through 1990, at 29 individual inflow points on the system.

[3] The use of the phrase "Baseline scenario" in this appendix regarding hydrologic modeling refers to the current operations of the LCR and should not be confused with the definition of "baseline" as used in the ESA regulations or CEQA. Similarly, the use of the phrase "Action Alternative scenario" in this appendix regarding hydrologic modeling refers to the future operations of the LCR.

Future Colorado River water demands were based on demand and depletion projections prepared by the Basin States. Depletions are defined as diversions from the river less return flow credits, where applicable. Return flow credits are applied when a portion of the diverted water is returned to the river system. In cases where there are no return flow credits associated with the diversions, the depletion is equal to the diversion. The simulated operation of Glen Canyon Dam, Hoover Dam and other elements of the Colorado River system were consistent with the LROC, applicable requirements for storage and flood control management, water supply deliveries to contractors and federal establishments in the Basin States, Indian tribes, and Mexico, and flow regulation downstream of the system dams.

J.6.1.2 Modeling Assumptions Common to Both the Baseline and Action Alternative Scenarios

Modeling of the river and reservoir system requires that certain assumptions be made with regard to various aspects of the water delivery and reservoir system operation. When analyzing the relative effects of different operating scenarios, it is important to maintain continuity among all other assumptions. The following assumptions are used for both the Baseline and Action Alternative scenarios.

Upper Basin Operations

The currently accepted operating rules for the Upper Basin reservoirs, including Lake Powell/Glen Canyon Dam, are used, as described in Attachment A. The currently accepted Upper Basin States' future depletion schedules are used, as detailed in the *Final Environmental Impact Statement for the Secretarial Implementation Agreement, Inadvertent Overrun and Payback Policy, and Related Federal Actions*, (Bureau of Reclamation 2002). The Upper Basin States' future depletion schedule increases over time are based on potential projects the Upper Basin States' have identified as projects that are likely to occur.

Lake Mead Operation

Lake Mead and Hoover Dam are operated in accordance with the Corps Flood Control procedures as described in Chapter 2 of the LCR MSCP BA and also in Attachment A of this appendix (see also *Colorado River Basin, Hoover Dam: Review of the Flood Control Regulations*, U.S. Army Corps of Engineers, July 1982). When not in flood control, Lake Mead is operated to meet downstream requirements, including depletions for the Lower Division States, Indian tribes, and Mexico (schedules as determined by Normal, Surplus, or Shortage conditions).

Lake Mohave and Lake Havasu Operation

These lakes are operated in accordance with their existing rule curves, as described in Section J.4.

Water Deliveries to the Republic of Mexico

Water deliveries to Mexico are made pursuant to the requirements of the 1944 Water Treaty. The model provides minimum annual deliveries of 1.515 maf to Mexico and up to 1.7 maf when there exists a surplus of waters in excess of the amount necessary to supply users in the United States and the guaranteed quantity of 1.5 maf annually to Mexico. For modeling purposes, the 1.7 maf is scheduled for delivery to Mexico when Lake Mead flood control or space building releases are required. The additional 15,000 af accounts for typical scheduling errors and over-deliveries.

Mexico's principal diversion is at Morelos Diversion Dam where most of its Colorado River apportionment is diverted. In practice, up to 140,000 af is delivered to Mexico near the SIB. Furthermore, some portion of Mexico's total apportionment can be delivered to the City of Tijuana, Baja Mexico. The model, however, extends to just south of the NIB to include the diversion at Morelos Diversion Dam and accounts for the entire 1944 Water Treaty delivery at that point.

Bypass Flows to Mexico

For the modeling conducted for this evaluation, the Yuma Desalting Plant depletion node in the model was set to 120,000 acre-feet per year (afy) from 2003–2022, representing the water (bypass flows) bypassed by the U.S. to the Cienega. For modeling purposes, this depletion is not counted as part of the deliveries to Mexico under the 1944 Water Treaty, which quantifies the provisional allotment of Colorado River water to be delivered to Mexico. The model assumes the desalting plant will operate beginning in 2023, reducing the depletion to 52,000 afy. This depletion is not counted as part of the deliveries under the 1944 Water Treaty. (The United States has an obligation to replace, as appropriate, the bypass flows, and the assumptions used in the model may not represent the policy that Reclamation will adopt for replacement of bypass flows.) The assumptions made with respect to modeling the bypass flows are intended only to provide a thorough and comprehensive accounting of Lower Basin water supply.

Reservoir Starting Conditions

The reservoir starting conditions (reservoirs' initial storage and elevation) that were used in the modeling of the various future operating conditions were the actual elevations as of December 31, 2002. These reservoir starting conditions are detailed in Attachment C. Additional information regarding reservoir starting conditions and other hydrologic information is also presented in Attachment E (which is also reproduced as Section III of Volume V).

J.6.1.3 Modeling Assumptions Specific to Each Operational Scenario

To analyze the potential impacts due to specific future flow-related actions (specific surplus and shortage guidelines and changes in the storage and delivery of state entitlement waters), the following modeling assumptions were different between the Baseline and Action Alternative scenarios:

- The amount of water scheduled and delivered to individual entities in the Lower Basin (i.e., water transfers),
- The determination of Surplus conditions for the Lower Basin, and
- The determination of Shortage conditions for the Lower Basin.

A description of the details that are specific for each modeled scenario follows.

Assumptions Specific to the Baseline Scenario

Water Transfers

Under the Baseline scenario, water transfers between specific entities in the Lower Basin were assumed at the amount and rate as described in the *Final Environmental Impact Statement for the Secretarial Implementation Agreement, Inadvertent Overrun and Payback Policy, and Related Federal Actions* (Bureau of Reclamation 2002). An additional transfer was assumed between PVID and Metropolitan to yield a total of 111,000 afy transferred, beginning in 2003.

Surplus Determination

Under the Baseline scenario, specific Interim Surplus Guidelines (ISG) as detailed in the *Record of Decision, Colorado River Interim Surplus Criteria, Final Environmental Impact Statement*, are in effect through calendar year 2016 (Bureau of Reclamation 2001). Additional explanation of this action is provided in Chapter 2 of the LCR MSCP BA.

Shortage Determination

To date, there have been no shortages in the Lower Basin and there are no established shortage criteria for the operation of Lake Mead. However, during the development of the ISG, it was necessary to include some shortage strategy in the modeling analysis to address concerns related to low Lake Mead water levels. Under the Baseline scenario for this study, the shortage strategy assumed were identical to those used for the development of the Interim Surplus Criteria EIS and are described below.

- **First Level Shortage:** The Lake Mead water level of 1,083 feet msl (the currently accepted minimum water level for effective power generation at the Hoover power plant) was designated as a level that should be protected. A first level shortage is triggered when Lake Mead's water level is below a "protection line" (or trigger elevation) at the beginning of the year. The protection line used in this analysis was developed in the mid-1990s using operational simulations (with stochastic hydrologic input) to protect the water level from declining below elevation 1,083 feet msl with approximately an 80 percent probability over a period of 50 years. The protection line used in the Baseline scenario is identical to that published in the *Final Environmental Impact Statement for the Interim Surplus Criteria* (Bureau of Reclamation 2000) and "Final Environmental Impact Statement for the Secretarial Implementation Agreement, Inadvertent Overrun and Payback Policy, and Related Federal Actions," (Bureau of Reclamation 2002).

During first level shortage conditions, the annual water delivery to the CAP was set to 1.0 maf, and SNWA was assigned a reduction in consumptive use of four percent of the total shortage.

- **Second Level Shortage:** A second level shortage would be determined to exist when the Lake Mead water surface elevation declined to 1,000 feet msl (the minimum water level necessary for operation of SNWA's lower water intake)

  During second level shortage conditions, the CAP and SNWA consumptive use would be reduced as needed to maintain the Lake Mead water level at 1000 feet msl. If the delivery to the CAP is reduced to zero and additional reduction is required to maintain Mead above 1,000 feet msl, deliveries to Metropolitan and to Mexico are also reduced. Such reductions to Metropolitan and Mexico did not occur in the simulations conducted for the LCR MSCP BA analysis.

  This strategy is commonly denoted by the abbreviation "80P1083/1000". This shorthand notation means the following:

  - shortage in the Lower Basin will occur to protect the Lake Mead elevation of 1,083 feet msl with approximately an 80 percent level of assurance, and
  - further shortages would be imposed to prevent Lake mead from falling below the elevation of 1,000 feet msl in any year.

The model assumes that the CAP would absorb all Arizona shortages. Reclamation acknowledges that under the current priority framework, there would be some sharing of Arizona shortage between the CAP and other Priority 4 users. However, the bases or formula for the sharing of Arizona shortages is the subject of current negotiations and as such, could not be adequately modeled for the evaluation.

Assumptions Specific to the Action Alternative Scenario

Water Transfers

Under the Action Alternative Scenario, water transfers that change the points of diversion were assumed at the amount and rate as described in Tables 2-14, 2-15, and 2-16 in the LCR MSCP BA[4]. These transfers include the 400,000 af assumed under the Baseline scenario.

To implement these transfers in the model, water demands were shifted amongst diversion points to achieve the necessary changes in the points of diversion, as described in Tables 2-14, 2-15, and 2-16. It should be noted, however, that no destinations were

[4] As noted in footnote "k" to Table 2-16 of the LCR MSCP BA, a reassignment of water from "Other Actions" to "MWD Transfer" was made between the Draft and Final LCR MSCP BAs. This reassignment would not affect Lake Mead storage and elevation and, therefore, the reservoir modeling was not updated.

assumed for the water transfers denoted "Reclamation Actions" in Tables 2-14, 2-15, and 2-16. Therefore, although that water was not delivered downstream, it was also not allowed to remain in Lake Mead (i.e., it was modeled as a "seepage loss" from Lake Mead so that direct comparisons of lake levels between the Baseline and Action Alternative scenarios could be made).

Surplus Determination

Under the Action Alternative Scenario, the ISG were assumed to be extended beyond 2016 and remain in effect through calendar year 2051.

Shortage Determination

Under the Action Alternative Scenario, the shortage assumptions were similar to those used in the Baseline scenario, with the exception of the specific elevations to be protected. Under a first level shortage, elevation 1,050 msl (the minimum water level necessary for operation of SNWA's upper water intake) would be protected with an approximate 80 percent probability. Under a second level shortage, elevation 950 feet msl would be protected. This strategy is commonly abbreviated as "80P1050/950."

J.6.1.4 Period of Analysis

The modeling and impact analyses for this appendix begins in year 2003 and extends through year 2051, for a total period of 49 years. It is important to note that modeling results and the associated impact analyses become more uncertain over time as a result of increased uncertainty of future hydrologic inflow conditions, as well as uncertainty with regard to future operational decisions.

J.6.1.5 Computational Procedures

The model was used to simulate the future state of the Colorado River system on a monthly basis, in terms of reservoir levels, releases from the dams, hydroelectric energy generation, flows at various points along the system and diversions to and return flows from various water contractors. The input data for the model included the monthly tributary inflows, various physical process parameters (such as the evaporation rates for each reservoir) and the diversion and depletion schedules for entities in the Basin States and Mexico. The common and specific operating criteria were also input for each alternative being studied.

Despite the differences in the operating criteria for the Baseline and the Action Alternative scenarios, the future state of the Colorado River system (i.e., water levels at Lake Mead and Lake Powell) is most sensitive to the future inflows. As discussed in Section J.4.1, observations over the period of historical record (1906–present) show that inflow into the system has been highly variable from year to year. Predictions of the future inflows, particularly for long-range studies, are highly uncertain. Although the model does not predict future inflows, it can be used to analyze a range of possible future inflows and to quantify the probability of particular events (i.e., lake levels being below or above certain levels).

Several methods are available for ascertaining the range of possible future inflows. On the Colorado River, a particular technique called the Index Sequential Method has been used since the early 1980s and involves a series of simulations, each applying a different future inflow scenario (Bureau of Reclamation 1985; Ouarda et al. 1997). Each future inflow scenario is generated from the historical natural flow record by "cycling" through that record. For example, the first simulation assumes that the inflows for 2003 through 2051 will be the 1906 through 1954 record, the second simulation assumes the inflows for 2003 through 2051 will be the 1907 through 1955 record, and so on. As the method progresses, the historical record is assumed to "wrap-around" (i.e., after the record reverts back to 1906), yielding a possible 85 different inflow scenarios. The result of the Index Sequential Method is a set of 85 separate simulations (referred to as "traces") for each operating criterion that is analyzed. This enables an evaluation of the respective criteria over a broad range of possible future hydrologic conditions using standard statistical techniques.

J.6.1.6 Post-Processing and Data Interpretation Procedures

The various analyses discussed and presented in this appendix required the sorting and arranging of various types of model output data into tabulations or plots of specific operational conditions, or parameters, at various points on the system. This was done through the use of statistical methods and other numerical analyses.

The river system model generates data on a monthly time step for some 300 points (or nodes) on the river system. Furthermore, through the use of the Indexed Sequential Method, the model generates 85 possible outcomes for each node for each month over the time period 2003 through 2051. These very large data sets are generated for each Action Alternative and Baseline scenarios and can be visualized as three-dimensional data "cubes" with the axes of time, space (or node) and trace (or outcome for each future hydrology). The data are typically aggregated to reduce the volume of data and to facilitate comparing the Action Alternative to Baseline scenarios and to each other. The type of aggregation varies depending upon the needs of the particular analysis. The post-processing techniques used for this appendix fall into two basic categories: those that aggregate in time, space or both, and those that aggregate the 85 possible outcomes.

For aggregation in time and space, simple techniques are employed. For example, lake elevations may be chosen on an annual basis (i.e., end of December) to show long-term lake level trends as opposed to short-term fluctuations.

Once the appropriate temporal and spatial aggregation is chosen, standard statistical techniques are used to analyze the 85 possible outcomes for a fixed time. Statistics that may be generated include the mean and standard deviation. However, the most common technique simply ranks the outcomes at each time (from highest to lowest) and uses the ranked outcomes to compute other statistics of interest. For example, if end-of-calendar year Lake Mead elevations are ranked for each year, the median outcome for a given year is the elevation for which half of the values are below and half are above (the median value or the 50th percentile value). Similarly, the elevation for which 25 percent of the values are less than or equal to in a given year, is denoted as the 25th percentile outcome.

These percentiles are often also termed "the percent of non-exceedance". Several presentations of the ranked data are then possible. A graph (or table) may be produced that compares the 90^{th} percentile, 75^{th} percentile, 50^{th} percentile, 25^{th} percentile, and 10^{th} percentile outcomes from 2003 through 2051 for the Baseline and Action Alternative.

It should be noted that a time series based on a statistic such as the 10^{th} percentile is not the result of any one hydrologic trace (i.e., no historical sequence seen in the past produced the 10^{th} percentile elevations). Rather, the 10^{th} percentile elevation for a specific year is the elevation for which only 10 percent of the outcomes for that year yielded an elevation that was less. As such, this type of analysis can been seen as a "worse case," when describing low percentiles (or conversely a "best case" when describing high percentiles). As a comparison, in the development of the Annual Operating Plan, three inflow scenarios for one year are typically run (the "minimum, maximum, and most probable" inflows). Often the minimum probable scenario is the historical annual inflow that has not been exceeded 10 percent of the time (or equivalently described as the inflow that has been exceeded 90 percent of the time). In this case, the minimum probable outcome is the direct result of an inflow that has been observed in the past, and therefore, probably does not represent the "worse case." This distinction is important when using the results of the modeling for subsequent biological and other resource impact analyses.

J.6.1.7 General Approach Used for Determining Potential Impacts

The analysis of the potential effects on specific river system components (e.g., lake levels) is based upon the results of the modeling previously described. Following the identification of conditions important to each component (e.g., maintaining a particular water level), various statistical summaries can be made (e.g., the probability of exceeding the elevation of interest). The potential effects of the Action Alternative are then presented in terms of the incremental differences in probabilities (or projected circumstances associated with a given probability) between Baseline and the Action Alternative.

J.6.1.8 Impacts Identified from the Modeling of Future Reservoir Operations

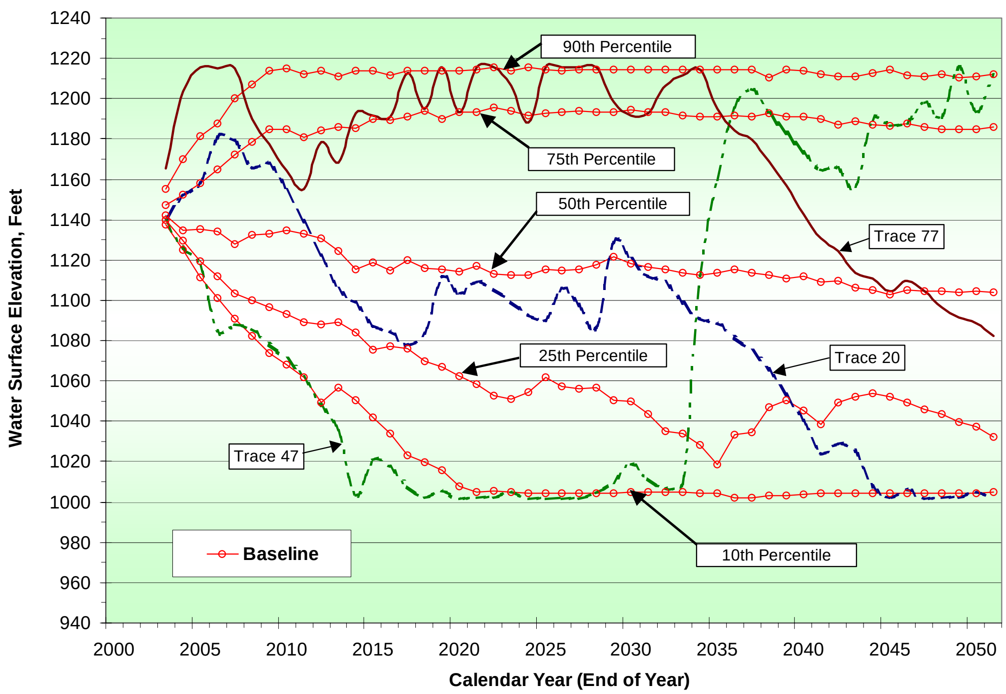
This section presents the modeling results for both the Baseline and Action Alternative scenarios. As previously mentioned, the only reservoir analyzed was Lake Mead.

This section provides a comparison of the results of the future Lake Mead water level simulations under Baseline and the Action Alternative. Lake levels are presented on an annual basis using water levels at the end of December for each year, when Lake Mead water levels are typically at a seasonal high.

Baseline Scenario

Under Baseline, the water surface elevation of Lake Mead is projected to fluctuate between full level and decreasingly lower levels during the period of analysis (2003–2051). Figure J-31 illustrates the range of future water levels by five lines, labeled 90th Percentile, 75th Percentile, 50th Percentile, 25th Percentile, and 10th Percentile. The 50th percentile line shows the median water level for each future year and is a measure of the central tendencies of the future water levels. The median water level under Baseline is shown to decline to 1,119 feet msl by 2015, to 1,115 feet msl by 2025, and to 1,104 feet msl by 2050.

Figure J-31
Lake Mead End-of-December Water Elevations under Baseline—
90th, 75th, 50th, 25th, and 10th Percentile Values and Representative Traces



One measure of the spread of the data, particularly in the middle range, is the inter-quartile range (the difference between the 75th and 25th percentile values). Using this measure, the spread is 39 feet msl in 2005, 114 feet msl in 2015, 131 feet msl in 2025, and 148 feet msl in 2050.

Three distinct traces are added to Figure J-31 to illustrate what was actually simulated under the various traces and respective hydrologic sequences and to highlight that the percentile lines do not represent simulated hydrologic outcomes, but rather the ranking of the data from the 85 traces for the conditions modeled. The three traces illustrate the variability among the different traces and that the reservoir levels could, over certain periods of time, temporarily decline below the 10th percentile line. The trace identified as Trace 20 represents the hydrologic sequence that begins in year 1926. The trace identified as Trace 47 represents the hydrologic sequence that begins in year 1953. The trace identified as Trace 77 represents the hydrologic sequence that begins in year 1983.

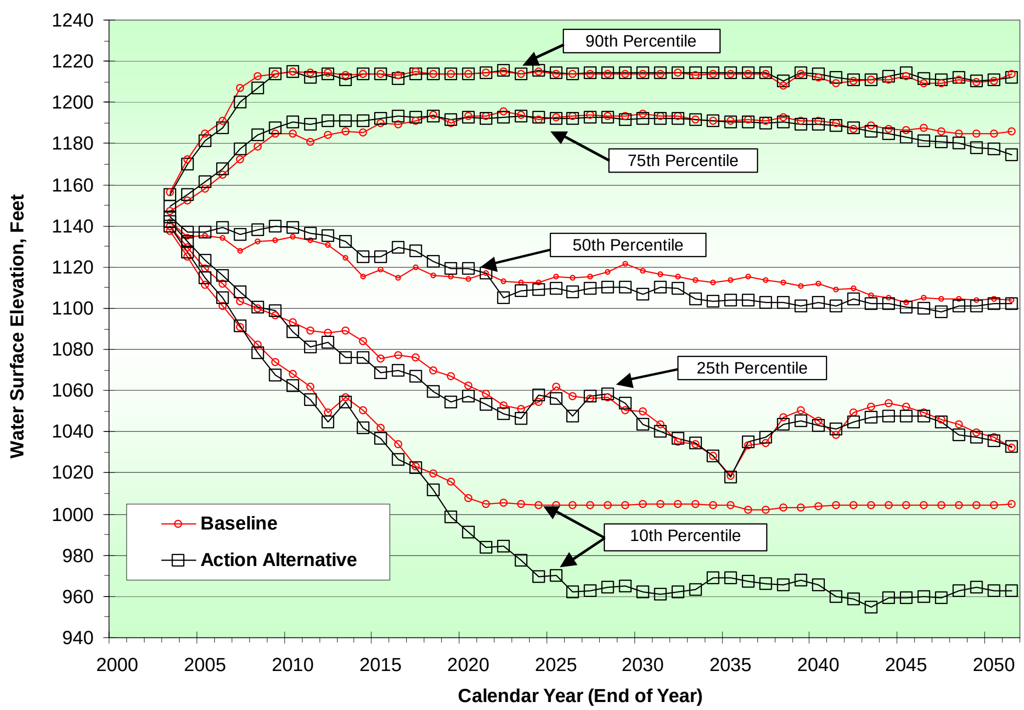
In Figure J-31, the 75th and 25th percentile lines bracket the range where the middle 50 percent of future Lake Mead water levels occur under Baseline. The highs and lows shown on the three traces would likely be temporary conditions. The reservoir level would tend to fluctuate through multi-year periods of above average and below average inflows. Neither the timing of water level variations between the highs and the lows, nor the length of time the water level would remain high or low can be predicted. These events would depend on the future variation in LCR Basin runoff conditions.

Figure J-31 also shows that median Lake Mead elevations decline throughout the period of analysis under Baseline. This effect is due to Lower Division depletions exceeding long-term inflow into Lake Mead. As depletions in the Upper Basin increase over time, the frequency of minimum objective releases (8.23 mafy) from Lake Powell is increased.

Comparison of Action Alternative to Baseline Scenarios

Figure J-32 presents a comparison of the 90th, 75th, 50th, 25th, and 10th percentile lines obtained under Baseline to those obtained for the Action Alternative. This figure is best used for comparing the relative differences between the general lake level trends that result from the simulation of the Baseline and Action Alternative scenarios.

Figure J-32
Lake Mead End-of-December Water Elevations—Comparison of Baseline to Action Alternative Scenarios for 90th, 75th, 50th, 25th, and 10th Percentile Values



As illustrated in Figure J-32, median Lake Mead elevations under the Action Alternative also decline throughout the period of analysis due to increasing Upper Basin depletions. Figure J-32 also illustrates that, up to 2020, median elevations are higher under the Action Alternative when compared to the Baseline Scenario (an average of approximately 5.3 feet msl higher over the period 2003–2020). This effect is explained by the positive effect that the water transfers have on Lake Mead levels. This positive effect is due to the fact that less water is delivered from Lake Mead when Surplus conditions are determined (i.e., the need for surplus water is diminished since that water has already been provided by the transfers). After 2020, at the median level, the positive effect due to the transfers is out-weighed by the effects of extending the Interim Surplus Guidelines to 2051 and lowering the shortage strategy (an average difference of approximately –6.7 feet msl over the period 2021–2050).

Figure J-32 also illustrates that at the lower percentiles, the Action Alternative could potentially result in lower Lake Mead water levels before 2020 when compared to Baseline, due to the diminished positive effect of the transfers at the lower lake levels (when surplus conditions are not in effect). At the 10th percentile, this effect is exaggerated by the shortage strategy assumed under the Action Alternative. Under that strategy, lake levels are allowed to decline below 1,000 feet msl since level 950 feet msl is protected at the second level.

As discussed above, under Baseline, future Lake Mead water levels at the 90th and 10th percentiles would likely be temporary and the water levels are expected to fluctuate between them in response to multi-year variations in basin runoff conditions. The same would apply under the Action Alternative. The 90th, 75th, 50th, 25th, and 10th percentile values of the Action Alternative are compared to those of Baseline in Table J-7. The values presented in this table after 2025 are for every five years.

Table J-7. Lake Mead End-of-December Water Elevations (feet msl)—Comparison of Baseline to Action Alternative Scenarios for 90th, 75th, 50th, 25th, and 10th Percentile Values

	Baseline					Action Alternative				
Year	90th Percentile	75th Percentile	50th Percentile	25th Percentile	10th Percentile	90th Percentile	75th Percentile	50th Percentile	25th Percentile	10th Percentile
2003	1155	1147	1142	1140	1138	1156	1149	1144	1142	1140
2004	1170	1152	1135	1129	1125	1172	1155	1137	1132	1127
2005	1181	1158	1135	1119	1111	1185	1161	1137	1123	1115
2006	1188	1165	1134	1112	1101	1191	1168	1139	1116	1105
2007	1200	1172	1128	1104	1091	1207	1177	1136	1108	1092
2008	1207	1178	1132	1100	1082	1213	1184	1138	1100	1078
2009	1214	1185	1133	1096	1074	1214	1188	1140	1099	1068
2010	1215	1185	1135	1093	1068	1215	1190	1139	1088	1063
2011	1212	1181	1133	1089	1062	1214	1189	1136	1081	1056
2012	1214	1184	1131	1088	1049	1214	1191	1135	1083	1045
2013	1211	1186	1125	1089	1057	1213	1191	1132	1076	1055
2014	1214	1186	1115	1084	1050	1214	1191	1125	1076	1042
2015	1214	1190	1119	1076	1042	1214	1192	1125	1069	1037
2016	1212	1190	1115	1077	1034	1213	1193	1130	1070	1026
2017	1214	1191	1120	1076	1023	1215	1193	1128	1067	1022
2018	1214	1194	1116	1070	1020	1214	1193	1123	1059	1012
2019	1214	1190	1115	1067	1016	1214	1191	1120	1054	999
2020	1214	1193	1114	1062	1008	1214	1193	1119	1057	991
2021	1214	1193	1117	1058	1005	1214	1192	1117	1053	984
2022	1215	1196	1113	1053	1006	1215	1193	1105	1049	984
2023	1214	1194	1113	1051	1005	1214	1193	1109	1046	977
2024	1215	1192	1113	1054	1004	1215	1193	1109	1058	970
2025	1214	1193	1115	1062	1004	1214	1192	1109	1056	970
2030	1214	1194	1118	1050	1005	1214	1192	1107	1043	962
2035	1214	1191	1114	1018	1004	1214	1190	1104	1018	969
2040	1214	1191	1112	1045	1004	1212	1190	1103	1043	966
2045	1214	1187	1103	1052	1004	1213	1183	1101	1048	959
2050	1211	1185	1104	1037	1005	1210	1177	1102	1036	963

Table J-8 provides more information on the general differences between the 90th, 75th, 50th, 25th, and 10th percentile lines of the Baseline and Action Alternative (same data presented in Figure J-32).

Table J-8. Comparison of Lake Mead End-of-December Water Elevations under Baseline and Action Alternative Scenarios—Average Difference in Feet between 90th, 75th, 50th, 25th, and 10th Percentiles

Period	Average Difference of 90th Percentile Values	Average Difference of 75th Percentile Values	Average Difference of 50th Percentile Values	Average Difference of 25th Percentile Values	Average Difference of 10th Percentile Values
2003–2015	2.1	4.5	5.3	-2.0	-2.2
2016–2025	0.0	0.0	1.9	-6.1	-18.9
2026–2051	-0.8	-2.6	-6.7	-1.9	-41.3

Figure J-33 provides a comparison of the frequency that future Lake Mead end-of-December water elevations under Baseline and the Action Alternative scenarios would be at or exceed a lake water elevation of 1,200 feet msl. The lines represent the percentage of values greater than or equal to the lake water elevation of 1,200 feet msl under the modeled Baseline and Action Alternative scenarios. In year 2015, under Baseline, the percentage of values greater than or equal to elevation 1,200 feet msl is 16.5 percent, in year 2025 the value is 16.5 percent, and in year 2050, the value decreases to 14.1 percent. The values for the Action Alternative generally follow the same pattern. In some years, the values are higher than those under Baseline and in others, the values are lower. Between years 2003 to year 2015, the values for the Action Alternative are an average of +1.1 percent higher than those of Baseline. Between years 2016 to year 2025, the values for the Action Alternative are an average of –0.2 percent lower than those of Baseline. Between years 2026 to year 2051, the values for the Action Alternative are an average of -1.0 percent lower than those of Baseline.

Figure J-33
Lake Mead End-of-December Water Elevations—Comparison of Baseline to Action Alternative Scenarios, Percentage of Values Greater than or Equal to Elevation, 1,200 Feet

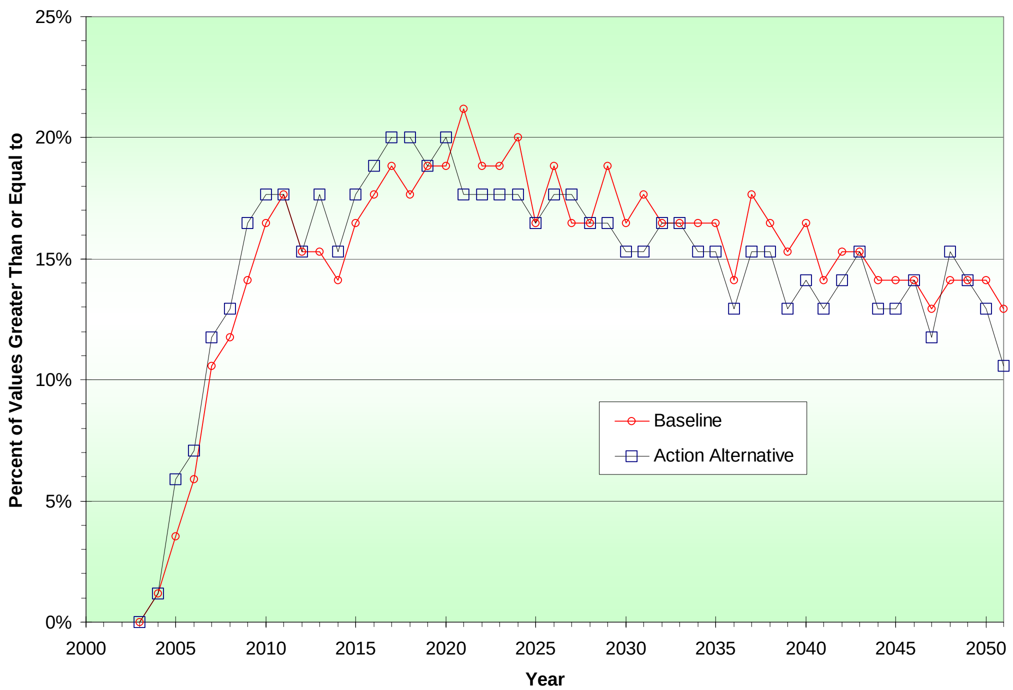


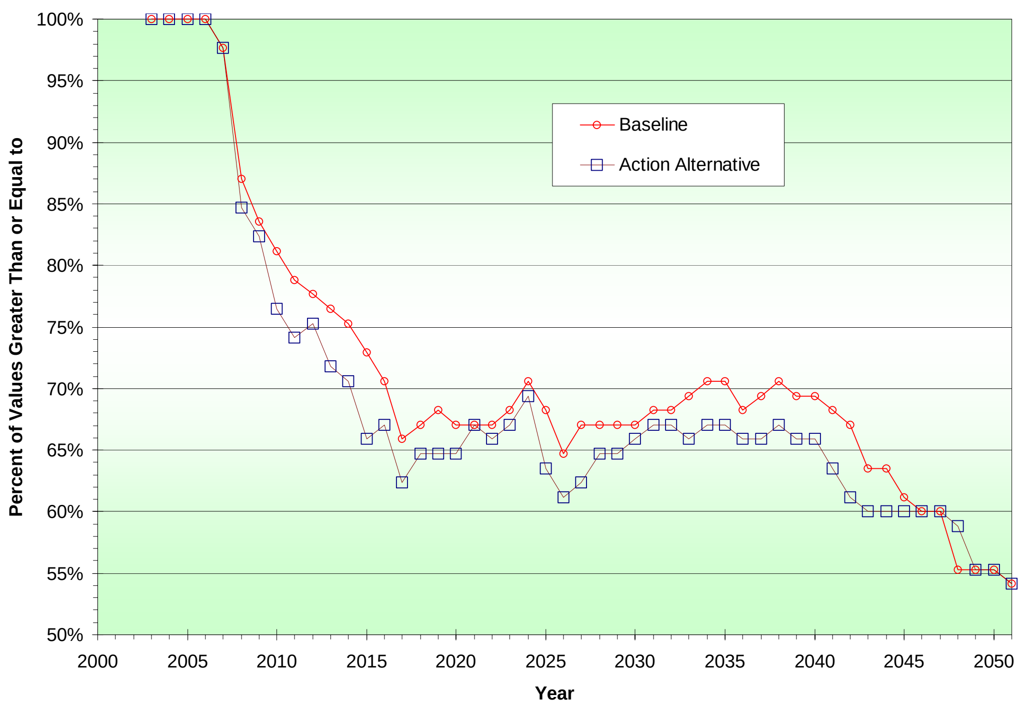
Table J-9 provides a numeric comparison and also the differences in the values for selected years between 2003 and 2051.

Table J-9. Comparison of Baseline to Action Alternative Scenarios for Lake Mead End-of-December Water Elevations—Percentage of Values Greater than or Equal to Elevation 1,200 Feet

Year	Baseline (%)	Action Alternative (%)	Difference (%) (Action Alternative–Baseline)
2003	0.0	0.0	0.0
2004	1.2	1.2	0.0
2005	3.5	5.9	2.4
2006	5.9	7.1	1.2
2007	10.6	11.8	1.2
2008	11.8	12.9	1.2
2009	14.1	16.5	2.4
2010	16.5	17.6	1.2
2011	17.6	17.6	0.0
2012	15.3	15.3	0.0
2013	15.3	17.6	2.4
2014	14.1	15.3	1.2
2015	16.5	17.6	1.2
2016	17.6	18.8	1.2
2017	18.8	20.0	1.2
2018	17.6	20.0	2.4
2019	18.8	18.8	0.0
2020	18.8	20.0	1.2
2021	21.2	17.6	-3.5
2022	18.8	17.6	-1.2
2023	18.8	17.6	-1.2
2024	20.0	17.6	-2.4
2025	16.5	16.5	0.0
2030	16.5	15.3	-1.2
2035	16.5	15.3	-1.2
2040	16.5	14.1	-2.4
2045	14.1	12.9	-1.2
2050	14.1	12.9	-1.2

Figure J-34 provides a comparison of the frequency that future Lake Mead end-of-December water elevations would be at or exceed a lake water elevation of 1,083 feet msl under Baseline and the Action Alternative Scenarios. For the period 2003 through 2010, under Baseline, the percentage of values greater than or equal to elevation 1,083 feet msl ranges from 100 percent to 81 percent. In year 2015, the percentage is 72.9 percent and decreases to 68 percent by 2025, remaining above 65 percent out to year 2042. Although the shortage strategy in effect for the Baseline (80P1083/1000) attempts to keep Lake Mead above elevation 1,083 msl with an 80 percent probability, the protection line (or trigger elevations) would need to be higher to achieve that that level of assurance.

Figure J-34
Lake Mead End-of-December Water Elevations—Comparison of Baseline to Action Alternative Scenarios, Percentage of Values Greater than or Equal to Elevation, 1,083 Feet



The values for the Action Alternative generally follow the same pattern, albeit at slightly lower levels. For the period 2003 through 2010, under the Action Alternative, the percentage of values greater than or equal to elevation 1,083 feet msl ranges from 100 percent to 76 percent. In year 2015, the percentage is 65.9 percent and decreases to 63.5 percent by 2025, remaining at or above 60 percent out to year 2047. The decrease in the percentages as compared to Baseline is a reflection of the different shortage strategy used in the Action Alternative (80P1050/950).

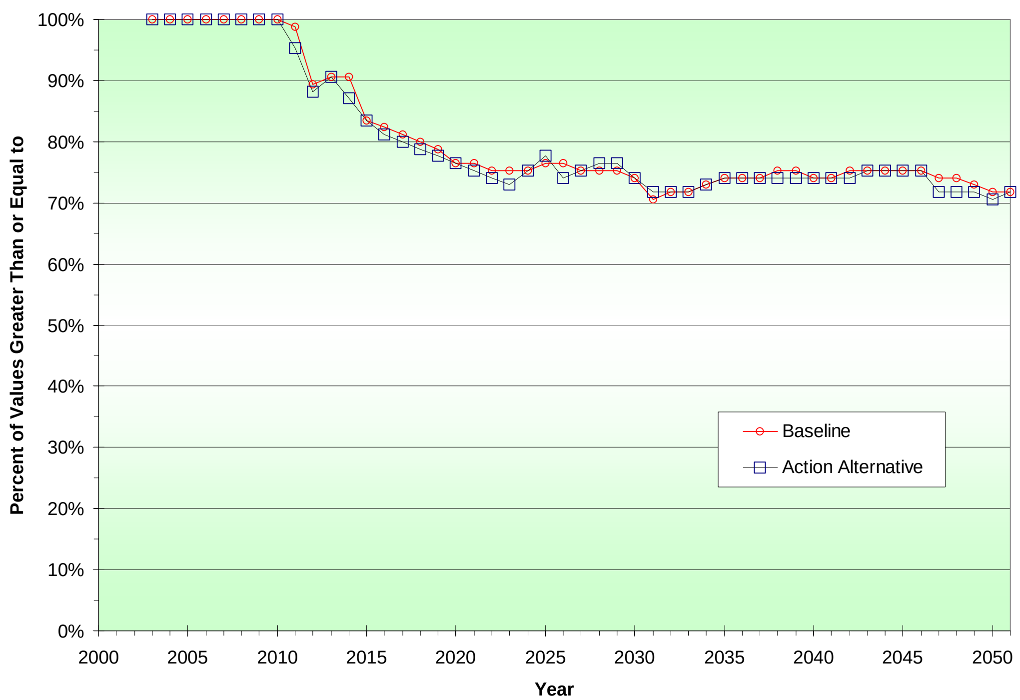
Table J-10 provides a numeric comparison and also the differences in the values for selected years between 2003 and 2051.

Table J-10. Comparison of Baseline to Action Alternative Scenarios for Lake Mead End-of-December Water Elevations—Percentage of Values Greater than or Equal to Elevation 1,083 Feet

Year	Baseline (%)	Action Alternative (%)	Difference (Action Alternative–Baseline)
2003	100.0	100.0	0.0
2004	100.0	100.0	0.0
2005	100.0	100.0	0.0
2006	100.0	100.0	0.0
2007	97.6	97.6	0.0
2008	87.1	84.7	-2.4
2009	83.5	82.4	-1.2
2010	81.2	76.5	-4.7
2011	78.8	74.1	-4.7
2012	77.6	75.3	-2.4
2013	76.5	71.8	-4.7
2014	75.3	70.6	-4.7
2015	72.9	65.9	-7.1
2016	70.6	67.1	-3.5
2017	65.9	62.4	-3.5
2018	67.1	64.7	-2.4
2019	68.2	64.7	-3.5
2020	67.1	64.7	-2.4
2021	67.1	67.1	0.0
2022	67.1	65.9	-1.2
2023	68.2	67.1	-1.2
2024	70.6	69.4	-1.2
2025	68.2	63.5	-4.7
2030	67.1	65.9	-1.2
2035	70.6	67.1	-3.5
2040	69.4	65.9	-3.5
2045	61.2	60.0	-1.2
2050	55.3	55.3	0.0

Figure J-35 provides a comparison of the frequency that future Lake Mead end-of-December water elevations would be at or exceed a lake water elevation of 1,050 feet msl under Baseline and the Action Alternative scenarios. For the period 2003 through 2010, under Baseline, the percentage of values greater than or equal to elevation 1,083 feet msl are all about 100 percent. In year 2015, the percentage is 83.5 percent, decreases to 76.5 percent by 2025, and fluctuates between 71.8 percent to about 76.6 percent through year 2051. As expected, the shortage strategy in effect for the Baseline (80P1083/1000) also serves to protect the lower level of 1,050 feet msl, albeit with an approximately 73 percent level of assurance.

Figure J-35
Lake Mead End-of-December Water Elevations—Comparison of Baseline to Action Alternative Scenarios, Percentage of Values Greater than or Equal to Elevation, 1,050 Feet



The values for the Action Alternative are nearly identical to the Baseline values. The largest deviation is a 3.5 percent difference in 2011 and 2014. Otherwise, the variations range between 0 and 2.4 percent.

Table J-11 provides a numeric comparison and also the differences in the values for years between 2003 and 2051.

Table J-11. Comparison of Baseline to Action Alternative Scenarios for Lake Mead End-of-December Water Elevations—Percentage of Values Greater than or Equal to Elevation 1,050 Feet

Year	Baseline (%)	Action Alternative (%)	Difference (%) (Action Alternative–Baseline)
2003	100.0	100.0	0.0
2004	100.0	100.0	0.0
2005	100.0	100.0	0.0
2006	100.0	100.0	0.0
2007	100.0	100.0	0.0
2008	100.0	100.0	0.0
2009	100.0	100.0	0.0
2010	100.0	100.0	0.0
2011	98.8	95.3	-3.5
2012	89.4	88.2	-1.2
2013	90.6	90.6	0.0
2014	90.6	87.1	-3.5
2015	83.5	83.5	0.0
2016	82.4	81.2	-1.2
2017	81.2	80.0	-1.2
2018	80.0	78.8	-1.2
2019	78.8	77.6	-1.2
2020	76.5	76.5	0.0
2021	76.5	75.3	-1.2
2022	75.3	74.1	-1.2
2023	75.3	72.9	-2.4
2024	75.3	75.3	0.0
2025	76.5	77.6	1.2
2030	74.1	74.1	0.0
2035	74.1	74.1	0.0
2040	74.1	74.1	0.0
2045	75.3	75.3	0.0
2050	71.8	70.6	-1.2

Figure J-36 provides a comparison of the frequency that future Lake Mead end-of-December water elevations under Baseline and the Action Alternative scenarios would be at or exceed a lake water elevation of 1000 feet msl. Under Baseline, the percentage of values greater than or equal to elevation 1000 feet msl generally are or are very close to 100 percent. This is a direct result of the shortage strategy used in the Baseline scenario (80P1083/1000), under which second level shortages are imposed to keep Lake Mead above elevation 1000 feet msl. Under the Action Alternative, the percentage of values greater than or equal to elevation 1000 feet msl generally stay at about 100 percent from 2003 to 2016. Thereafter, the values decrease to about 82 percent by year 2050. These results again reflect the difference in the shortage strategies used under the two modeled scenarios.

Figure J-36
Lake Mead End-of-December Water Elevations—Comparison of Baseline to Action Alternative Scenarios, Percentage of Values Greater than or Equal to Elevation, 1000 Feet

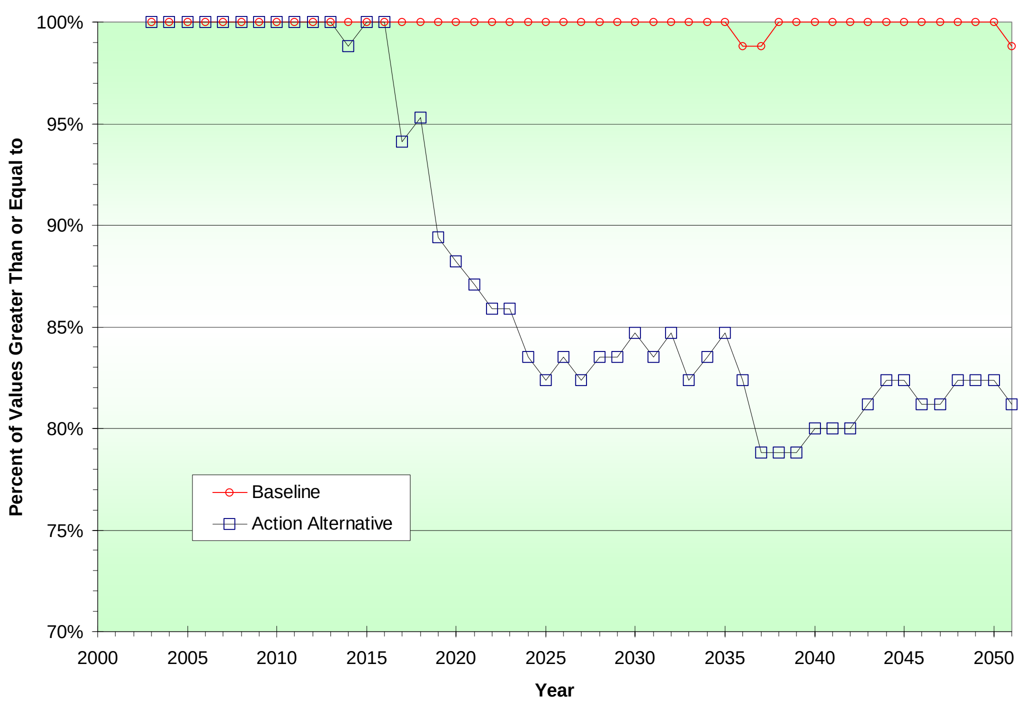


Table J-12 provides a numeric comparison and also the differences in the values for selected years between 2003 and 2051.

Table J-12. Comparison of Baseline to Action Alternative Scenarios for Lake Mead End-of-December Water Elevations—Percentage of Values Greater than or Equal to Elevation 1,000 Feet

Year	Baseline (%)	Action Alternative (%)	Difference (%) (Action Alternative–Baseline)
2003	100.0	100.0	0.0
2004	100.0	100.0	0.0
2005	100.0	100.0	0.0
2006	100.0	100.0	0.0
2007	100.0	100.0	0.0
2008	100.0	100.0	0.0
2009	100.0	100.0	0.0
2010	100.0	100.0	0.0
2011	100.0	100.0	0.0
2012	100.0	100.0	0.0
2013	100.0	100.0	0.0
2014	100.0	98.8	-1.2
2015	100.0	100.0	0.0
2016	100.0	100.0	0.0
2017	100.0	94.1	-5.9
2018	100.0	95.3	-4.7
2019	100.0	89.4	-10.6
2020	100.0	88.2	-11.8
2021	100.0	87.1	-12.9
2022	100.0	85.9	-14.1
2023	100.0	85.9	-14.1
2024	100.0	83.5	-16.5
2025	100.0	82.4	-17.6
2030	100.0	84.7	-15.3
2035	100.0	84.7	-15.3
2040	100.0	80.0	-20.0
2045	100.0	82.4	-17.6
2050	100.0	82.4	-17.6

Figure J-37 provides a comparison of the frequency that future Lake Mead end-of-December water elevations under Baseline and the Action Alternative scenarios would be at or exceed a lake water elevation of 950 feet msl. Under Baseline, the percentage of values greater than or equal to elevation 950 feet msl are always 100 percent. This is a direct result of the shortage strategy used in the Baseline scenario (80P1083/1000), under which second level shortages are imposed to keep Lake Mead above elevation 1000 feet msl. Under the Action Alternative, the percentage of values greater than or equal to elevation 950 feet msl are 100 percent from 2003–2020. From 2021–2051, the values are at or above 92 percent, due to the uncertainty in projecting the end-of-year water surface elevation at the beginning of each year. However, subsequent analysis showed that the shortage strategy protects Lake Mead elevation 937 feet msl 100 percent of the time through 2051.

Figure J-37
Lake Mead End-of-December Water Elevations—
Comparison of Baseline to Action Alternative Conditions,
Percentage of Values Greater than or Equal to Elevation, 950 feet msl

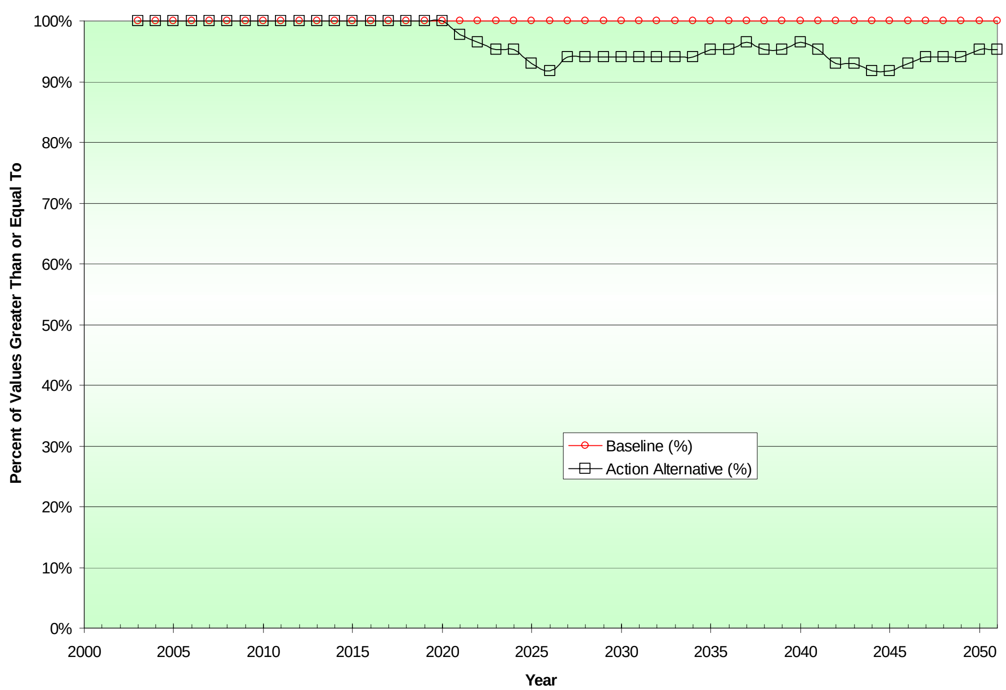


Table J-13 provides a numeric comparison and also the differences in the values for selected years between 2003 and 2051.

Table J-13. Comparison of Baseline to Action Alternative Conditions for Lake Mead End-of-December Water Elevations—Percentage of Values Greater than or Equal to Elevation 950 Feet

Year	Baseline (%)	Action Alternative (%)	Difference (%) (Action Alternative–Baseline)
2003	100.0	100.0	0.0
2004	100.0	100.0	0.0
2005	100.0	100.0	0.0
2006	100.0	100.0	0.0
2007	100.0	100.0	0.0
2008	100.0	100.0	0.0
2009	100.0	100.0	0.0
2010	100.0	100.0	0.0
2011	100.0	100.0	0.0
2012	100.0	100.0	0.0
2013	100.0	100.0	0.0
2014	100.0	100.0	0.0
2015	100.0	100.0	0.0
2016	100.0	100.0	0.0
2017	100.0	100.0	0.0
2018	100.0	100.0	0.0
2019	100.0	100.0	0.0
2020	100.0	100.0	0.0
2021	100.0	97.6	-2.4
2022	100.0	96.5	-3.5
2023	100.0	95.3	-4.7
2024	100.0	95.3	-4.7
2025	100.0	92.9	-7.1
2030	100.0	94.1	-5.9
2035	100.0	95.3	-4.7
2040	100.0	96.5	-3.5
2045	100.0	91.8	-8.2
2050	100.0	95.3	-4.7

J.6.2 Hydrologic Impacts to the River Corridor (Reaches 3–5)

As discussed in Section J.6.1, a reservoir model was used to project the possible future conditions of the lower Colorado River system under a range of possible future inflow conditions. When analyzing impacts to the river, backwaters, and groundwater along the Colorado River corridor below Hoover Dam, more detail is necessary. Accordingly, Reclamation used a more detailed analysis to assess the potential impacts to covered species and their habitat along the river corridor.

This section describes the methodology used to determine the effects on downstream river flow and stage due to potential future reductions in releases from Davis and Parker Dams. The analysis of the effects on downstream river flow and stage was used in subsequent analyses to assess the impacts to open water (both river and backwaters), groundwater connected to the river channel, and finally to marsh and riparian habitat as a result of the potential future changes in flow. See Appendix K and Chapter 5 of the LCR MSCP BA.

J.6.2.1 Description of the Methodology

The effects on downstream river flow and stage due to potential future reductions in releases from Davis and Parker Dams were analyzed. Flow reductions of up to 0.845 mafy in the river from Hoover Dam to Davis Dam (Reach 2), up to 0.860 mafy in the river from Davis Dam to Parker Dam (Reach 3), and up to 1.574 mafy in the river from Parker Dam to Imperial Dam (Reaches 4 and 5) were considered (See Chapter 2 of the LCR MSCP BA, Table 2-13). As noted above, impacts in Reaches 2 and 6 of such reductions were determined to be insignificant and were therefore not modeled.

The methodology employed for this analysis comprised the following general steps:

1. Estimate the hourly flows likely to be released from the dams, both before and after the flow reductions have been applied
2. Route the hourly release patterns downstream to locations of interest[5]
3. Convert the modeled flows at each location to river stage (elevation) to determine the reduction in river stage due to the flow reduction
4. Determine the effects of the reduction in river stage to backwater area extent and depth, and to depth to groundwater proximate to the river

Given the changes in backwater and groundwater due to the flow reductions, the potential impacts to habitat could then be computed. This section describes Steps 1 through 3 in more detail. Step 4 is described in Appendix K.

[5] Thirteen locations were selected downstream of Davis Dam and are shown in the first column of Table J-15. Twenty locations were selected downstream of Parker Dam and are shown in the first column of Table J-17. The criteria used for the selection of the locations of interest are discussed in Appendix K.

Estimate the Hourly Releases

As discussed in Appendix K, it was assumed that changes in river stage would cause an immediate effect to backwaters that are directly connected to the river. Therefore, to obtain a "worse case" analysis, the largest reduction in river stage was needed at each location along the river on an hourly basis. Furthermore, since hourly release patterns from Davis and Parker Dams vary seasonally as shown in Figure J-23 and J-30, the hourly reductions in river stage would need to be examined on a seasonal basis to obtain a "worse case."

Consequently, for the analysis of effects on directly connected backwaters, typical releases from each dam for the months of April, August, and December were chosen as reference flows, from which to apply the flow reductions. Since the flow reductions were specified on an annual basis (see Tables 2-14–2-16 in Chapter 2 of the LCR MSCP BA), a typical schedule of diversions from the particular reach were used to distribute the annual reduction by month. Once the monthly releases were known (both before and after reductions), the release was disaggregated into a mean daily flow by simply dividing by the number of days in the month. Use of monthly reference flows will be referred to the "Monthly" analysis in this appendix.

As noted in Section J.4.3, typical hourly releases at Parker and Davis Dams vary throughout the year primarily due to the magnitude of the scheduled water orders. From historical data, Reclamation determined relationships that relate the typical hourly release patterns to the mean daily releases from each dam. This methodology is described in more detail in a report entitled *Analysis of Water Transfer Effects on Flows and Elevations at Selected Sites along the Lower Colorado River* (Bureau of Reclamation 2002a). The mean daily release for each dam was then disaggregated to hourly releases by using the appropriate relationship.

As discussed in Appendix K, it was assumed that changes in river stage would not immediately affect backwaters indirectly connected to the river as well as groundwater near the river. Consequently, for the analysis of the effects to indirectly connected backwaters and groundwater, a typical annual release for each dam was chosen as the reference flow from which to apply the flow reductions. The annual releases (before and after reductions) were then converted to mean daily flows by simply dividing by the number of days in the year. The mean daily release for each dam was then disaggregated to hourly releases by using the appropriate relationship as described above and documented in Reclamation (2002a). Use of an annual reference flow is referred to as the "Average Annual" analysis in this appendix[6].

Route the Hourly Releases Downstream

Once the hourly releases from each dam were determined, these flows were routed downstream, using a river routing model based on the "Muskingum Method" for channel flow analysis (HEC-1 User's Manual, U.S. Army Corps of Engineering, March 1987). The model was calibrated based on an analysis of historical flows as measured at various

[6] The "Average Annual" analysis is also referred to as "Annual Median" in other LCR MSCP documents (e.g., in Appendix K and Chapter 5 of the BA).

stream gages below Davis and Parker Dams.[7] Reclamation frequently uses this method and from past experience, Reclamation has determined that this method generally provides good correlation and reliability of values over a wide range of flows (Bureau of Reclamation 2002(a)). Flows at other locations of interest not at a gage site were assumed to be the same as flows at the gage site nearest the location.

Convert the Modeled Flows to River Elevation (Stage)

The modeled flows at each location were then converted to river elevation or stage. This conversion was achieved with the use of a rating formula that was developed for each site using output from the Army Corps of Engineers water surface profile model, HEC-RAS (Bureau of Reclamation 1999). River channel cross section survey data was used to develop and verify the accuracy of the water surface profiles and the resulting rating formulas.

For the Average Annual analysis, the hourly flows at each location were first aggregated to mean daily flows, which were then converted to stage. This was done for the flows before and after the respective flow reductions. The decrease in river stage (or drawdown) due to the flow reduction was then computed at each location. For the Monthly analysis, the minimum hourly flow at each location was first converted to stage and then the drawdown was computed.

J.6.2.2 Modeled Davis Dam Releases

An annual release from Davis Dam of approximately 9.2 maf was assumed for the reference release from which to apply the 0.860 mafy flow reduction. For the Monthly analysis, a historical year was chosen with approximately the same annual release in order to choose the reference releases for April, August, and December.

Following the methodology outlines above, two sets of hydrographs were developed to reflect the river flow conditions below Davis Dam before and after the release reductions. Each hydrograph set represented two scenarios: Average Annual, and Monthly for April, August and December. The hydrograph set that reflects the river flow conditions before the release reductions is hereinafter referred to as "Reference Release" or "Reference Flow." The hydrograph set that reflects the river flow conditions with the release reductions is hereinafter referred to as "Reduced Release" or "Reduced Flow."

The Average Annual analysis is presented in this section. The results of the Monthly analyses are presented in Attachment D.

For Davis Dam releases, three downstream gages were used to calibrate the model. These sites are shown for in Table J-14.

[7] The gage sites below Davis and Parker Dams are listed in Tables J-14 and J-16 respectively.

Table J-14. Gage Locations between Davis Dam and Parker Dam

River Location	River Mile
Big Bend	265.9
Topock Marsh Inlet	244.3
Topock Gorge Stream Gage	231.0

Figure J-38 compares the hourly Davis Dam releases for the annual median under the modeled Reference to Reduced Release scenarios. The modeled flows for the Reduced Release scenario reflect an annual reduction of 860,000 af compared to the Reference Release scenario. Figure J-39 compares the river stage at one of the 14 locations downstream of Davis Dam (near the inlet to Topock Marsh). These stage levels correlate with the flows shown for the respective hours on Figure J-38.

Figure J-38
Comparison of Davis Dam Release and River Flow near Topock Marsh Inlet under Reference to Reduced Flow Scenarios (860 kaf Release Reduction)

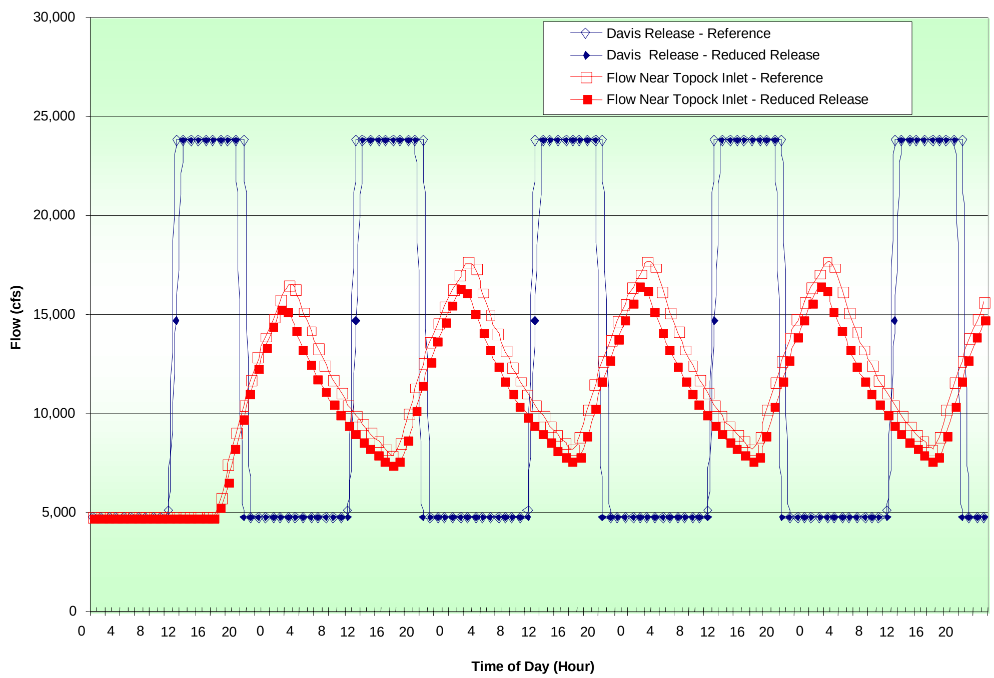
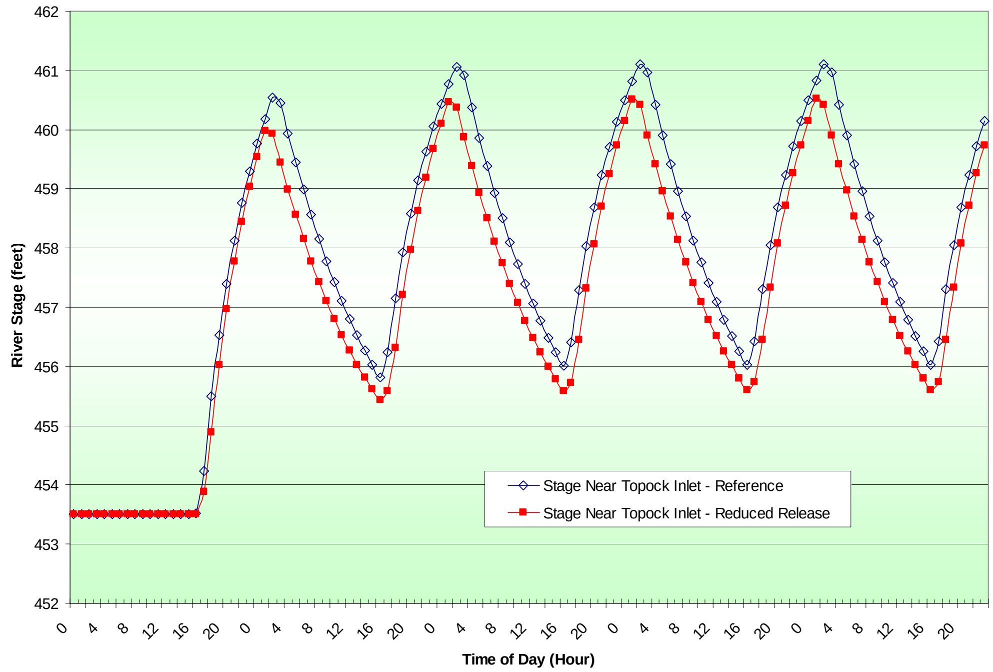


Figure J-39
Comparison of River Stage Near Topock Marsh Inlet Under Reference to Reduced Flow Scenarios (860 kaf Release Reduction)



The hourly flows at each of the 14 locations were then aggregated to mean daily flows and converted to river stage, for both the Reference and Reduced Release scenarios. Table J-15 presents these flows and river stages at each location. The maximum river stage difference over all locations was observed to be 0.65 feet msl at River Mile 243.9.

The results of the Monthly Analyses for flow reductions below Davis Dam are presented in Attachment D.

Table J-15. Comparison of River Stage for Selected Locations along the Lower Colorado River between Davis Dam and Parker Dam, Average Annual Analysis, Reference to Reduced Release Scenarios (860 kaf Release Reduction)

	Reference Release		860 kaf Reduced Release		Differences	
Location (RM)	Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)	Change in Flow (cfs)	Change in Stage (feet)
Davis Dam Release	12,708	N/A	11,520	N/A	-1,188	N/A
270.5	12,708	497.67	11,520	497.28	-1,188	-0.40
267.2	12,708	490.67	11,520	490.24	-1,188	-0.43
262.9	12,708	478.73	11,520	478.14	-1,188	-0.58
255.1	12,708	470.16	11,520	469.56	-1,188	-0.60
259.6	12,708	475.16	11,520	474.59	-1,188	-0.57
248.9	12,708	464.21	11,520	463.61	-1,188	-0.60
243.9	12,708	458.69	11,520	458.04	-1,188	-0.65
240.8	12,708	456.89	11,520	456.29	-1,188	-0.61
237.6	12,708	454.14	11,520	453.59	-1,188	-0.55
234.7	12,492	452.44	11,305	451.93	-1,187	-0.51
229.8	12,492	449.99	11,305	449.53	-1,187	-0.47
225.0	12,492	448.76	11,305	448.41	-1,187	-0.35
220.2	12,492	447.52	11,305	447.31	-1,187	-0.21

J.6.2.3 Modeled Parker Dam Releases

An annual release from Parker Dam of approximately 7.3 maf was assumed for the reference release from which to apply the 1.574 maf flow reduction. For the Monthly analysis, a historical year was chosen with approximately the same annual release in order to choose the reference releases for April, August, and December.

Following the methodology outlines above, two sets of hydrographs were developed to reflect the river flow conditions below Parker Dam before and after the release reductions. Each hydrograph set represented two scenarios: Average Annual, and Monthly for April, August and December. The hydrograph set that reflects the river flow conditions before the release reductions is hereinafter referred to as "Reference Release" or "Reference Flow." The hydrograph set that reflects the river flow conditions with the release reductions is hereinafter referred to as "Reduced Release" or "Reduced Flow."

The Average Annual analysis is presented in this section. The results of the Monthly analysis are presented in Attachment D.

1 For Parker Dam releases, four downstream gages were used to calibrate the model.
2 These sites are listed in Table J-16.

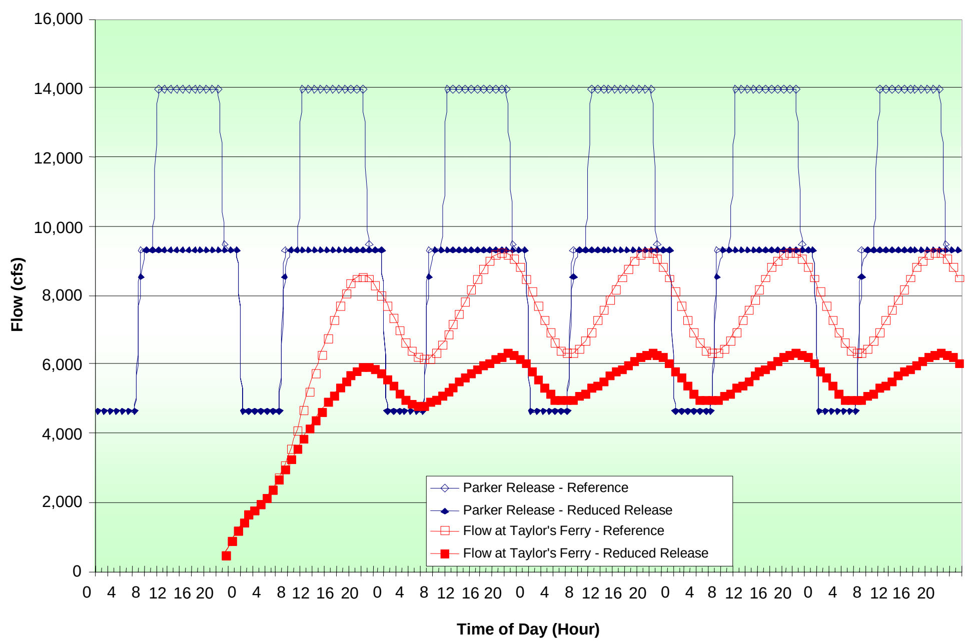
3 **Table J-16.** Gage Locations between Parker Dam and Imperial Dam

River Location	River Mile
Waterwheel gage	152.0
Taylor Ferry gage	106.6
Cibola gage	87.3
Imperial Dam gage	49.2

4

5 Figure J-40 compares the hourly Parker Dam releases under the modeled Reference to
6 Reduced Release scenarios. The modeled flows for the Reduced Release scenario reflect
7 an annual reduction of 1.574 maf compared to the Reference Flow scenario. Figure J-41
8 compares the river stage at one of the 20 locations downstream of Parker Dam (near
9 Taylor Ferry). These stage levels correlate with the flows shown for the respective hours
10 on Figure J-40.

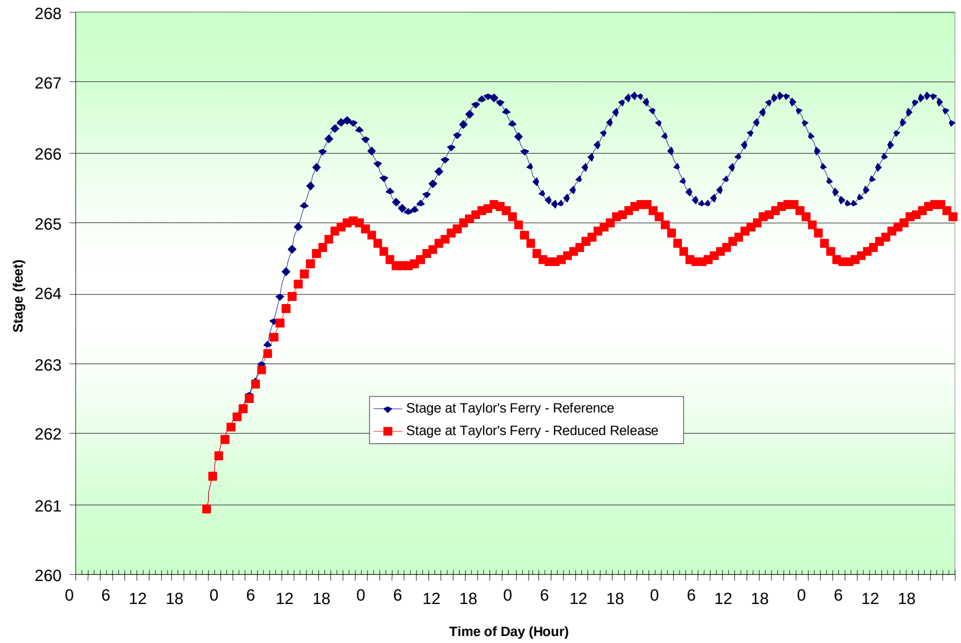
11 **Figure J-40**
12 **Comparison of Parker Dam Release and River Flow near Taylor Ferry under Reference to**
13 **Reduced Flow Scenarios (1.574 maf Release Reduction)**



14

15

Figure J-41
Comparison of River Stage Near Taylor Ferry Under Reference to Reduced Flow Scenarios (1.574 maf Release Reduction)



The hourly flows at each of the 20 locations were then aggregated to mean daily flows and converted to river stage, for both the Reference and Reduced Release scenarios. Table J-17 presents the flows and river stages at each location. The maximum river stage difference over all locations was observed to be 1.55 feet msl at River Mile 116.5.

The results of the Monthly Analyses for flow reductions below Parker Dam are presented in Attachment D.

Table J-17. Comparison of River Stage for Selected Locations along the Lower Colorado River between Parker Dam and Imperial Dam, Average Annual Analysis, Reference to Reduced Release Scenarios (1.574 maf Release Reduction)

	Reference Release		1.574 maf Reduced Release		Differences	
Location (RM)	Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)	Change in Flow (cfs)	Change in Stage (feet)
Parker Dam Release	10,083	N/A	7,911	N/A	-2,172	N/A
171.3	8,474	334.12	6,302	332.98	-2,172	-1.14
167.6	8,474	327.66	6,302	326.43	-2,172	-1.23
160.9	8,474	316.12	6,302	314.92	-2,172	-1.20
149.5	8,474	298.96	6,302	297.74	-2,172	-1.22
146.9	8,474	295.52	6,302	294.57	-2,172	-0.95
135.8	8,474	283.83	6,302	283.70	-2,172	-0.13
119.7	7,796	248.26	5,624	247.09	-2,172	-1.17
116.5	7,796	241.93	5,624	240.38	-2,172	-1.55
114.6	7,796	239.50	5,624	238.05	-2,172	-1.45
109.1	7,796	230.96	5,624	229.53	-2,172	-1.44
103.1	7,796	224.50	5,624	223.28	-2,172	-1.22
96.7	7,796	215.98	5,624	214.55	-2,172	-1.43
86.1	8,860	207.15	6,689	205.99	-2,171	-1.16
80.4	8,860	202.15	6,689	201.18	-2,171	-0.96
72.2	8,860	194.28	6,689	193.26	-2,171	-1.02
70.3	8,860	193.24	6,689	192.20	-2,171	-1.04
66.1	8,860	189.20	6,689	188.17	-2,171	-1.03
56.0	8,856	183.93	6,686	183.05	-2,170	-0.88
53.6	8,856	180.97	6,686	180.48	-2,170	-0.49
50.8	8,856	179.70	6,686	179.62	-2,170	-0.08

J.7 References Cited

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Attachment A

Detailed Modeling Documentation

Attachment A
Detailed Modeling Documentation

This attachment describes the reservoir operating rules and related data used in the U.S. Department of the Interior, Bureau of Reclamation's (Reclamation's) Colorado River Simulation System (CRSS), as implemented in the RiverWare modeling system.

J.A.1 Background

Long-term policy and planning studies on the Colorado River have typically used model results from the CRSS, a Fortran-based modeling system, developed in the 1980s. CRSS originally ran on a Cyber mainframe computer, but was ported to run on both personal computers and Unix Workstations in 1994. CRSS modeled twelve major reservoirs and some 115 diversion points throughout the Upper and Lower Basins on a monthly time step. A major drawback of CRSS was that the operating policies or rules were "hardwired" into the modeling code, making modification of those policies difficult.

Based on the need to initiate surplus and shortage studies for the Lower Basin in the early 1990s, Reclamation developed an annual time step model, CRSSez (Bureau of Reclamation 1998). CRSSez primarily models the operation of Lakes Powell and Mead, representing the reservoirs above Powell as one aggregate reservoir, and the effect of reservoirs below Mead as part of the water demand necessary from Mead. CRSSez was used in the Interim Surplus Criteria EIS process to facilitate the development of possible alternatives to be analyzed.

Also in 1994, Reclamation began a collaborative research and development program with the University of Colorado and the Tennessee Valley Authority with the goal of developing a general-purpose modeling tool that could be used for both operations and planning on any river basin. This modeling tool, known as RiverWare, is now being used by the Upper and Lower Colorado Regions for both planning and monthly operations (Fulp 1999). A major advantage of RiverWare is that the operational policies or rules are no longer "hardwired" into the modeling code (Zagona et al. 2001). The user expresses and prioritizes the rules through the RiverWare graphical user interface, and RiverWare then interprets the rules when the model is run. Multiple rule sets can be run with the same model and this provides the capability for efficient "what-if" analysis with respect to different policies.

Reclamation replaced the original CRSS model with a new model implemented in RiverWare in 1996. The new model has the same spatial and temporal resolution, uses the same basic input data (hydrology and consumptive use schedules), and uses the same physical process algorithms as the original CRSS. A rule set was also developed to mimic the policies contained in the original model. Comparison runs were made between the original CRSS and the new model and rule set, with typical differences of less than 0.5 percent (Bureau of Reclamation 1996).

The second phase of the program to replace CRSS consists of examining the rules extracted from CRSS and developing new rule sets that reflect current operational policy as well as to investigate and improve, where necessary, the physical process methodologies. A team of Reclamation engineers from the Upper and Lower Colorado Regions has been established for these purposes and this phase is ongoing. The operation rules for Lake Powell were updated in 1999. As new operational policies are determined in the Upper Basin, the associated rules will be updated.

J.A.2 Description of the Model

As previously mentioned, the features represented in the model are identical to the original CRSS model. In summary, twelve reservoirs are modeled (Fontenelle, Flaming Gorge, Taylor Park, Blue Mesa, Morrow Point, Crystal, Navajo, Starvation, Powell, Mead, Mohave, Havasu) and approximately 115 diversions are modeled (demands and return flows) throughout the basin. The hydrologic "natural" inflows (flows corrected for upstream regulation and consumptive uses and losses) at 29 inflow points throughout the basin were also used from the standard CRSS hydrology data set covering the period 1906–1990.

A summary of the operating rules for each reservoir follows.

J.A.3 Reservoirs above Lake Powell

The reservoirs above Lake Powell are operated to meet monthly storage targets (or “rule curves”) and downstream demands. The basic procedure is that given the inflow for the current month, the release will be either the release necessary to meet the target storage or the release necessary to meet demands downstream of the reservoir, whichever is greater. The rule curves are input for each reservoir, but are modified during the run for Flaming Gorge, Blue Mesa, and Navajo to simulate operations based on the imperfect inflow forecasts that are encountered in actual reservoir operations. Furthermore, each reservoir is constrained to operate within user-supplied minimum and maximum releases (mean monthly release in cubic feet per second [cfs]) as specified in the following table:

Reservoir	Minimum Release	Maximum Release
Fontenelle	500	18,700
Flaming Gorge	800	4,900
Starvation	100	5,000
Taylor Park	50	5,000
Blue Mesa	270	5,000
Morrow Point	300	5,000
Crystal	300	4,200
Navajo	300	5,900

For Flaming Gorge, Blue Mesa, and Navajo, the target storage is computed by using an inflow forecast for the spring runoff season (January–July), again to mimic the imperfect forecasts seen in actual operations. The forecasted inflow (for the current month through July) is computed as a weighted average of the long-term average natural inflow and the natural inflow assumed for the year being modeled. The weights used are:

Month	Natural Inflow Weight	Average Natural Inflow weight
January	0.3	0.7
February	0.4	0.6
March	0.5	0.5
April	0.7	0.3
May	0.7	0.3
June	0.7	0.3
July	0.6	0.4

The long-term, average natural inflows into each reservoir are (1000 acre-feet [af]):

Reservoir	Jan	Feb	Mar	Apr	May	Jun	Jul
Flaming Gorge	23.3	20.9	33.8	87.9	250.4	327.8	157.5
Blue Mesa	34.0	39.5	94.6	176.0	339.8	561.6	346.8
Navajo	18.8	24.6	69.3	176.9	297.3	284.7	120.1

Based on the inflow forecast, the rule computes the volume necessary to release from the current month through July, assuming the reservoir will fill in July:

> Release needed for the current month = (current contents - live capacity + predicted remaining inflow) divided by the number of months remaining until the end of July

The target storage for the current month is then computed, adjusting for any gains or losses above the reservoir:

Target storage = previous storage - release needed + gains - losses

J.A.4 Lake Powell Operation

As previously stated, the operation of Lake Powell was modified to reflect current operating polices in 1999. In the original CRSS rules, Lake Powell was operated on a rule curve that was not adjusted for an inflow forecast. Two other higher priority rules ensured that the minimum objective release of 8.23 million acre-feet per year (mafy) was met and that equalization of Lakes Powell and Mead was accomplished when necessary.

The rule curve operation of Lake Powell was replaced by a new rule that better represents current operational practices. This new rule consists of a forecast-driven, spring runoff operation (January through July) that attempts to fill the reservoir to a July target storage and a fall operation (August through December) that attempts to draw down the reservoir to a December target storage. For this EIS, the July and December targets were 23.822 million acre-feet (maf) (500,000 af of space) and 21.900 maf (2.422 kaf of space) respectively. In addition, a rule was added to simulate the occurrence of Beach Habitat Building Flows (BHBFs or “spike” flows). The minimum objective release and equalization rules were kept essentially the same as in the original CRSS rules. Release constraints that reflect the 1996 Record of Decision on the Operation of Glen Canyon Dam were also added to the Lake Powell rule set.

J.A.5 Lake Powell Inflow Forecast

Since the original CRSS rules computed an inflow forecast for Lake Powell and adjusted it for use by the flood control operation at Lake Mead, the same forecasting algorithm could be applied to the new operation of Lake Powell. The unregulated Lake Powell inflow forecast from the current month through July is computed as:

Unregulated Lake Powell inflow = natural flow into Lake Powell - estimated Upper Basin depletions + the forecast error

where; the forecast error is computed using equations derived from an analysis of past Colorado River forecasts and runoff data for the period 1947 to 1983.

As detailed in the original CRSS overview document (Bureau of Reclamation 1985), analysis of these data revealed two strongly established patterns: (1) high runoff years are under-forecast, and low runoff years are over-forecast; (2) the error in the current month's seasonal forecast is strongly correlated with the error in the preceding month's forecast. A regression model was developed to aid in determining the error to be incorporated into the seasonal forecast for each month from January to June. The error is the sum of a deterministic and a random component. The deterministic component is computed from the regression equation. The random component is computed by multiplying the standard error of the regression equation by a random mean deviation selected from a standard normal distribution.

The forecast error equation has the following form (all runoff units are maf):

$$E_i = a_i X_i + b_i E_{(i-1)} + c_i + Z_r d_i$$

where:

- i = month,
- E_i = error in the forecast for month "i,"
- X_i = natural runoff into Lake Powell from month "i" through July,
- a_i = linear regression coefficient for X_i,
- $E_{(i-1)}$ = previous month's forecast error,
- b_i = linear regression coefficient for $E_{(i-1)}$,
- c_i = constant term in regression equation for month "i,"
- Z_r = randomly determined deviation, and
- d_i = standard error of estimate for regression equation for month "i."

The following table summarizes the regression equation coefficients for each month:

Month	a_i	b_i	c_i	d_i
January	0.70	0.00	-8.195	1.270
February	0.00	0.80	-0.278	0.977
March	0.00	0.90	0.237	0.794
April	0.00	0.76	0.027	0.631
May	0.00	0.85	0.132	0.377
June	0.24	0.79	0.150	0.460

The magnitude of the June forecast error is constrained to not exceed 50 percent of the May forecast error and the July forecast error is equal to 25 percent of the June forecast error.

J.A.6 Spring Runoff Operation (January–July)

To accomplish the spring operation, the unregulated forecast is first adjusted to account for potential reservoir regulation above Powell. This potential regulation is currently computed as just the sum of the available space (live capacity – previous month’s storage) in Fontenelle, Flaming Gorge, Blue Mesa, and Navajo. Using the regulated forecasted inflow, the total volume of water necessary to release from the current month through July is computed as:

total volume to release = previous storage – July target storage

+ forecasted regulated inflow – loss due to evaporation–loss due to bank storage

The release for the current month is then computed by multiplying the total volume to release by a fraction for the current month, where the fraction reflects a user-supplied preferred weighting pattern. The weights and resulting fractions used for this study are as follows:

Spring Season	Weights	Fractions
January	0.170	0.170
February	0.160	0.193
March	0.130	0.194
April	0.100	0.185
May	0.100	0.227
June	0.160	0.471
July	0.180	1.000

The fraction is computed as current month's weight divided by the sum of the current and remaining month's weights for the season.

During the spring operation, however, the computed release is constrained to be at least as great as the total volume divided by the number of months remaining. This constraint ensures that sufficient water is released early in the season during high forecast years. Lake Powell’s spring operational release is further constrained in each month to be within a minimum and maximum range (currently set to 6,500 and 25,000 cfs, respectively).

J.A.7 Fall Operation (August–December)

Conceptually, the computation for the fall operation is identical to that done for the spring operation. The regulated inflow forecast is simply the natural inflow, adjusted for Upper Basin depletions, and potential reservoir regulation with no forecast error added. The potential reservoir regulation is again computed as the sum of the available space in Fontenelle, Flaming Gorge, Blue Mesa, and Navajo, where the space is the target storage in December for each reservoir minus the previous month’s storage. User-supplied weights are also used to compute the current month release from the total volume to release in the fall. The weights and resulting fractions are as follows:

Fall Season	Weights	Fractions
August	0.266	0.266
September	0.200	0.272
October	0.156	0.292
November	0.156	0.413
December	0.222	1.000

Two additional constraints are placed on the computed monthly release to ensure a smooth operation. In July, the release is constrained to be at least 1.0 maf if Powell's storage is greater than 23.0 maf. From July through December, the release is constrained to not exceed 1.5 maf, as long as a 1.5 maf release results in a storage at Lake Powell less than 23.822 maf. Powell's fall operational release is further constrained in each month to be within a minimum and maximum range (currently set to 6,500 and 25,000 cfs, respectively).

J.A.8 Minimum Objective Release

A higher priority rule ensures that the previously described Powell operation will satisfy a minimum objective release to the Lower Basin, currently equal to 8.23 maf over each water year (October through September). Similar to the weighting and release fraction scheme used for the operational rule, a preferred release pattern for each month to meet the minimum objective release is supplied and a fraction is computed. The release pattern (in kaf) and resulting fractions are as follows:

Month	Release	Fraction
October	600	0.073
November	600	0.079
December	700	0.100
January	800	0.126
February	700	0.127
March	600	0.124
April	600	0.142
May	600	0.165
June	700	0.231
July	800	0.343
August	900	0.588
September	630	1.000

The fraction is computed as current month's release divided by the sum of the current and remaining month's releases through September.

Each month the rule computes the volume of water remaining to meet the minimum objective release for the current water year (accounting for the water released previously in the water year) and multiplies that volume by the release fraction. The release determined by the operational rule must then be at least as great as this resulting minimum objective release for the month.

J.A.9 Equalization of Lakes Powell and Mead

The equalization of storage between Lakes Powell and Mead is implemented in a rule that first determines if equalization needs to occur, and if so, then determines how much water to release from Powell to accomplish it. The rule is in effect from January through September of each year. The rule states that equalization needs to occur if two criteria are met: (1) if the storage in the Upper Basin meets the 602(a) requirement, and (2), if the projected end-of-water-year (EOWY) storage in Lake Powell is greater than that in Lake Mead.

The storage in the Upper Basin is computed for each month (January–September) and consists of the predicted EOWY storage in Lake Powell, plus the sum of the previous month’s storage for Flaming Gorge, Blue Mesa, and Navajo. That storage is then compared to the computed value of 602(a) storage, described below to see if the 602(a) requirement is met each month. The method of estimating the EOWY storage is described below.

The release for equalization is computed by taking half of the difference between the predicted EOWY contents of Lake Powell and Lake Mead and dividing by the number of months remaining through September. Evaporation and bank storage losses at Lakes Powell and Mead are included in the calculation, resulting in an iterative procedure to arrive at the computed equalization release. The iteration stops when the forecasted EOWY contents of Lake Powell and Lake Mead are within a user-specified tolerance. That tolerance is currently set to 25,000 af.

The computed equalization release for each month is constrained in three ways. If the additional release due to equalization would cause the total Upper Basin storage to drop below the 602(a) requirement, then the amount of the equalization release is reduced to prevent this from happening. Likewise, the equalization release is reduced if it would cause Lake Mead contents to exceed its exclusive flood control space. Finally, the equalization release is constrained to be less than or equal to the maximum power plant capacity at Lake Powell (currently set to 33,100 cfs).

J.A.10 602(a) Storage Requirement

As stated in the CRSS overview document (Bureau of Reclamation 1985), “602(a) storage refers to the quantity of water required to be in storage in the Upper Basin so as to assure future deliveries to the Lower Basin without impairing annual consumptive uses in the Upper Basin.” The current implementation of that storage requirement duplicates the original CRSS calculation. It computes the storage necessary in the Upper Basin to meet the minimum objective release and Upper Basin depletions over the next “n” years, assuming the inflow over that period would follow that seen in the most “critical period on record.” The critical period in the Colorado River basin occurred in 1953–1964, a length of 12 years. Inflows from these years are used in the calculation of 602(a) storage.

At the beginning of each calendar year, a value for 602(a) storage is computed by the following formula:

602a = {(UBDepletion + UBEvap)* (1 – percentShort/ 100) + minObjRel – criticalPeriodInflow} * 12 + minPowerPoolStorage

where:

- 602a = the 602(a) storage requirement
- UBDepletion = the average over the next 12 years of the Upper Basin scheduled depletions
- UBEvap = the average annual evaporation loss in the Upper Basin (currently set to 560 kaf)
- percentShort = the percent shortage that will be applied to Upper Basin depletions during the critical period (currently set to zero)
- minObjRel = the minimum objective release to the Lower Basin (currently set to 8.23 maf)
- criticalPeriodInflow = average annual natural inflow into the Upper Basin during the critical period (1953–1964) (currently set to 12.18 maf)
- minPowerPoolStorage = the amount of minimum power pool to be preserved in Upper Basin reservoirs (currently set to 5.179 maf)

All parameter values currently used were as found in the original CRSS data files ported from the Cyber mainframe in 1994.

J.A.11 Predicting End-of-Water-Year Contents of Lakes Powell and Mead

Lake Powell EOWY content is predicted each month by taking the previous month's storage, adding the estimated inflow, subtracting the estimated release, and subtracting the estimate of evaporation and change in bank storage. All estimated values are for the period from the current month through September. The estimated inflow is just the regulated inflow forecast previously discussed, where the forecast error is included through July. The estimated release is based on the spring operation (through July) and the fall operation for August and September. The estimated evaporation and bank storage losses are based on an initial estimate of the EOWY content.

Similarly, the Lake Mead EOWY content is predicted each month by taking the previous month's content, adding the estimated Powell release, subtracting the estimated Mead release, adding the average gain between Powell and Mead, subtracting the Southern Nevada depletion, and subtracting the estimate of evaporation and change in bank storage. Again, all values are for the period from the current month through September. Lake Mead's release is estimated as the sum of the depletions downstream of Mead and the reservoir regulation requirements (including evaporation losses) for Lakes Mohave and Havasu minus the gains below Mead.

J.A.12 Beach /Habitat Building Flows

Under the current rule that implements BHBFs, a BHBF is triggered for the current month if the following conditions are met:

- In January, if the unregulated inflow forecast for January through July (the natural flow – Upper Basin depletions plus forecast error) is greater than the "January trigger volume" (currently set to 13.0 maf).
- In January through July, if the current month's Powell release is greater than the "release trigger" (currently set to 1.5 maf) or if the release volume for the current month through July equally distributed over those months would result in a release greater than the "release trigger."

Once a BHBF has been triggered, if Powell would have had to spill in that month anyway, the total outflow from Powell is not increased; rather the volume for the BHBF (currently set to 200 kaf) is taken from the total outflow already determined by the operational rule. If Powell was not going to spill in that month, then the total outflow from Powell is increased (i.e., the volume for the BHBF is taken from Powell's storage). Under the case where the BHBF is triggered even though the current month's release is less than the "release trigger", the rule re-sets Powell's outflow for that month to the trigger release amount (1.5 maf).

Under all circumstances, only one BHBF is made per calendar year.

J.A.13 Lake Mead Operation

Lake Mead is operated primarily to meet downstream demand, including downstream depletions (both U.S. and Mexico) and reservoir regulation requirements. In any month, the rule computes the downstream depletions based on schedules that have been set as input data or by other rules (for the case of surplus or shortage in the Lower Basin). The reservoir regulation requirements for Lakes Mohave and Havasu include water necessary to meet their storage targets and evaporation losses for each month. The operation rule computes the release necessary from Lake Mead to meet that total downstream demand minus gains below Mead. This release may be increased, however, based on flood control procedures.

J.A.14 Mead Flood Control

There are three flood control procedures currently in effect for different times of the year. These procedures were developed in the original CRSS and were based on the Field Working Agreement between Reclamation and the Corps (U.S. Army Corps of Engineers 1982). The first procedure is in effect throughout the year. Its objective is to maintain a minimum space of 1.5 maf in Lake Mead, primarily for extreme rain events. This space is referred to as the exclusive flood control space and is represented by the space above elevation 1,219.61 msl. The second procedure is used during the spring runoff forecast season (January–July). The objective during this period is to route the maximum forecasted inflow through the reservoir system using specific rates of Hoover Dam discharge, assuming that the lake will fill (to elevation 1,219.61 msl) at the end of July. The third procedure is used during the space building or drawdown period (August–December). The objective during this period is to gradually draw down the reservoir system to meet the total system space requirements in each month in anticipation of the next year's runoff.

J.A.15 Exclusive Flood Control Space Requirement

As previously noted, this requirement states that space in Lake Mead must be a minimum of 1.5 maf at all times. If the release computed to meet downstream demand results in a Lake Mead storage that would violate this space requirement, the rule computes the additional release necessary to maintain that space.

J.A.16 Spring Runoff Season (January–July)

The flood control policy requires that the maximum forecast be used where that forecast is defined as the estimated inflow volume that, on average, will not be exceeded 19 times out of 20 (a 95 percent non-exceedance). The rule first computes the inflow forecast to Lake Mead by taking the Lake Powell forecast previously described and adds the long-term, average natural tributary inflows between Lakes Powell and Mead. The maximum forecast is then estimated by adding an additional volume (the "forecast error term") to that inflow forecast. The forecast error term (in maf) is given in the following table, taken from the original CRSS data:

Forecast Period	Forecast Error Term
January–July	4.980
February–July	4.260
March–July	3.600
April–July	2.970
May–July	2.525
June–July	2.130
July–July	0.750

The Field Working Agreement defines an iterative algorithm by which the current month's release (in cfs) is determined. Certain release levels are specified and are given in the following table:

Release Level	Release	Description
1	19,000	Parker Power Plant capacity
2	28,000	Davis Power Plant capacity
3	35,000	Hoover Power Plant capacity (in 1987)
4	40,000	Approximate maximum flow non-damaging to streambed
5	73,000	Hoover controlled discharge capacity

The flood control release needed for the current month is determined by:

> release needed for the current month = maximum forecasted inflow – current storage space in Lake Powell (below 3,700 feet) – current storage space in Lake Mead (below 1,229 feet) + 1.5 maf (exclusive space) – evaporation and bank storage losses from Lakes Powell and Mead – Southern Nevada depletion – future volume of water released (assuming a release level from the table for the remaining months through July)

If the computed release for the current month is greater than that assumed for the future months, the future level is increased and the current month release is re-computed. The computation stops once the computed release for the current month is less than or equal to that assumed for the future months. If the computed release is greater than the previously assumed level, that release is used for the current month; otherwise, the previously assumed level is used.

The rule sets Lake Mead's release to the flood control release if it is greater than the release previously computed to meet downstream demands.

J.A.17 Space Building (August–December)

The flood control policy states the flood control storage space (in maf) in Lake Mead (storage below elevation 1,229 feet) required at the beginning of each month from August through January:

Date	Space Required
August	1.50
September	2.27
October	3.04
November	3.81
December	4.58
January	5.35

However, these targets may be reduced to the minimum of 1.5 maf in each month if additional space is available upstream in active storage. Certain upstream reservoirs are specified with a maximum creditable space (in maf) for each:

Reservoir	Maximum Creditable Storage Space
Powell	3.8500
Navajo	1.0359
Blue Mesa	0.7485
Flaming Gorge plus Fontenelle	1.5072

In each month (July–December), if the release computed to meet downstream demands results in an end-of-month Lake Mead storage that would violate the space requirement adjusted for upstream storage, the rule computes the additional release necessary to maintain that space. However, these releases are constrained to be less than or equal to 28,000 cfs.

J.A.18 Lake Mohave and Lake Havasu Operation

Lakes Mohave and Havasu are operated to meet a user-specified target storage at the end of each month. These storage targets (in kaf) are given in the following table:

Month	Mohave Target Storage	Havasu Target Storage
January	1644.0	539.1
February	1698.7	539.1
March	1698.7	557.4
April	1698.7	593.6
May	1753.9	611.4
June	1666.0	611.4
July	1543.0	580.0
August	1417.0	561.1
September	1371.1	557.4
October	1371.1	548.2
November	1478.0	542.7
December	1585.0	539.1

J.A.19 Lower Basin Shortage Strategies

To date, there have been no shortages to the Lower Division States and there are no established shortages. However for the development of the Interim Surplus Guidelines in 1999, shortage rules were developed and used in the model simulation to address concerns related to low Lake Mead elevations. A “two-level” shortage protection strategy was used.

In Level 1 shortage, the shortage determination is based on comparing the January 1 Lake Mead elevation to a user-input trigger elevation, where the trigger elevations are determined from other modeling studies to protect a significant elevation within a given degree of confidence. If Lake Mead’s elevation at the beginning of the year is less than the trigger elevation, a Level 1 shortage is declared and certain Lower Basin depletions are reduced. The shortage remains in effect for that calendar year.

Level 1 protection of elevation 1,083 feet (minimum power pool) and Level 1 protection of elevation 1,050 feet (minimum water level for operation of Southern Nevada’s upper diversion intake) were used in this study. Trigger elevations were input to protect each elevation with an approximately 80 percent probability; however, actual model runs showed that the protection was less. Under Level 1 shortage, the Central Arizona Project (CAP) depletion is set to a given amount (1.0 maf for this draft environmental impact statement) and Southern Nevada Water Authority (SNWA) is reduced by 4 percent of the total reduction as given by:

$$SNWS_{short} = SNWS_{norm} – (0.04*(CAP_{norm}-CAP_{short})/0.96)$$

Where: the subscripts denote the normal and shortage depletion amounts. The Metropolitan Water District of Southern California (MWD) and other water users (including Mexico) do not take a Level 1 shortage.

Under Level 2 shortages, further cuts are imposed to keep Lake Mead above a specified elevation (both 1,000 feet and 950 feet were used in this study). At the beginning of each year, the rule estimates the EOWY Lake Mead elevation (using Level 1 shortage schedules and normal schedules for other users). If the EOWY elevation is below the 2nd level protection elevation, CAP and SNWA are cut further to keep Lake Mead above that elevation. If CAP delivery is reduced to zero, MWD and Mexico have shortages imposed, again in an amount necessary to keep the reservoir above the specified elevation. Shortages to Mexico consist of shorting Mexico proportionately to the total shortages imposed on United States users:

$$Mex_{short} = Mex_{norm} * (U.S._{shortage}/U.S._{norm})$$

J.A.20 Lower Basin Surplus Strategy

The model assumes that the Interim Surplus Guidelines (ISG) are in effect through calendar year 2016, unless otherwise noted. The ISG are specified in the Record of Decision (ROD), Colorado River ISG, Final Environmental Impact Statement, January, 2001, and the model implements those as follows:

Normal Conditions

If the modeled January 1 Lake Mead elevation is below 1,125 feet msl, the model assigns the Normal schedules to all diversion points in the Lower Basin. The Normal schedules total 7.5 maf of annual consumptive use in the Lower Basin.

Partial Domestic Surplus

If the modeled January 1 Lake Mead elevation is at or above 1,125 feet msl and below 1,145 feet msl, the model assigns the Partial Domestic Surplus schedules to MWD and the SNWA. All other diversion points remain at Normal schedules. The Partial Domestic Surplus schedules yield the amount of surplus for MWD and SNWA as specified in the ROD, and are documented in the Final Environmental Impact Statement, Implementation Agreement, Inadvertent Overrun and Payback Policy, and Other Federal Actions (SIA-EIS, Bureau of Reclamation 2002).

Full Domestic Surplus

If the modeled January 1 Lake Mead elevation is at or above 1,145 feet msl but below the spill avoidance strategy assuming the runoff value of the 70th percentile of exceedance based on the historic record of runoff above Lake Powell (i.e., the 70R Strategy), the model assigns the Full Domestic Surplus schedules to MWD and SNWA. All other diversion points remain at Normal schedules. The Full Domestic Surplus schedules yield the amount of surplus for MWD and SNWA as specified in the ROD, and are documented in the SIA-EIS (Bureau of Reclamation 2002).

Quantified Surplus (70R Strategy)

If the modeled January 1 Lake Mead storage provides insufficient space for the coming year (based on the 70R Strategy), and is below the flood control release criteria listed below, the Secretary would determine annually the quantity of surplus water available. The quantity is determined by assuming the 70th percentile historical runoff, along with normal 7.5 maf delivery to Lower Division states, for the next year. Applying these values to current reservoir storage, the projected reservoir storage at the end of the next year is calculated. The surplus is determined if the estimated space available at the end of the next year is less than the space needed by flood control criteria. The quantity of the surplus is the difference between the space required and the estimated available space. Once the quantity of surplus water is known, the model computes each state's share (50 percent to California, 46 percent to Arizona, and 4 percent to Nevada). The model then assigns the Full Domestic Surplus schedules to MWD and SNWA. Arizona's share of the surplus is assigned to the CAP, up to their Full Surplus schedule. If surplus water is still available for California, up to 300 kaf is made available to the Imperial Irrigation District (IID) and the Coachella Valley Water District (CVWD).

Flood Control Surplus

If the modeled January 1 system contents projects Hoover Dam flood control releases based on the Field Working Agreement between Reclamation and the Corps (U.S. Army Corps of Engineers 1982), the model assigns the Full Surplus schedules to MWD, SNWA, CAP, IID, and CVWD. All other diversion points remain at Normal schedules. The Full Surplus schedules are documented in the SIA-EIS (Bureau of Reclamation 2002).

J.A.21 References

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Attachment B

Sensitivity Analysis

Evaluation of the Incremental Effects of Flow-Related Actions Being Considered Under the LCR MSCP (Specific Surplus and Shortage Strategies and Changes in the Points of Delivery of State Entitlement Waters)

Attachment B
Sensitivity Analysis

J.B.1 Introduction

This attachment to Appendix J is intended to provide a summary of the evaluation that was conducted to determine the incremental effects on Lake Mead water levels that may result from the implementation of flow-related actions being considered under the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) (specific surplus and shortage guidelines and changes in the points of delivery of state entitlement waters). For this analysis, the following specific actions were studied:

1. water transfers, as specified in Tables 2-14–2-16 of the LCR MSCP BA;
2. extension of the effective period of the Interim Surplus Guidelines (ISG) from 2003 to 2016 through 2003 to 2051; and
3. lower Lake Mead shortage protection (from the 80P1083/1000 strategy to the 80P1050/950 strategy (see Section J.6 for a description of these strategies).

The main text of Appendix J focused strictly on evaluating the combined effects of the three specific actions. This sensitivity analysis considers the implementation of these actions both independently or in a paired combination. Specifically, the following action alternative scenarios were evaluated:

Action Alternative 1A. Assumes only the specific action of water transfers. This alternative is used to evaluate the effects of the future water transfers.

Action Alternative 1B. Assumes only that the ISG period is extended to 2051. This alternative is used to evaluate the effects of extending the effective period of the ISG beyond 2016.

Action Alternative 1C. Assumes only the lowering of the shortage protection from 80P1083/1000 to 80P1050/950. This alternative is used to evaluate the effects of lowering the Lake Mead shortage protection.

Action Alternative 1D. Assumes that both the ISG period is extended to 2051 and the shortage protection is lowered, but without future water transfers. This alternative is used to evaluate the combined effects of extending the ISG and lowering the Lake Mead shortage protection.

Action Alternative. Assumes that all three specific actions occur. This is the Action Alternative considered and discussed throughout Appendix J. It is used to evaluate the combined effects of the future water transfers, extending the effective period of the ISG, and lowering the Lake Mead shortage protection.

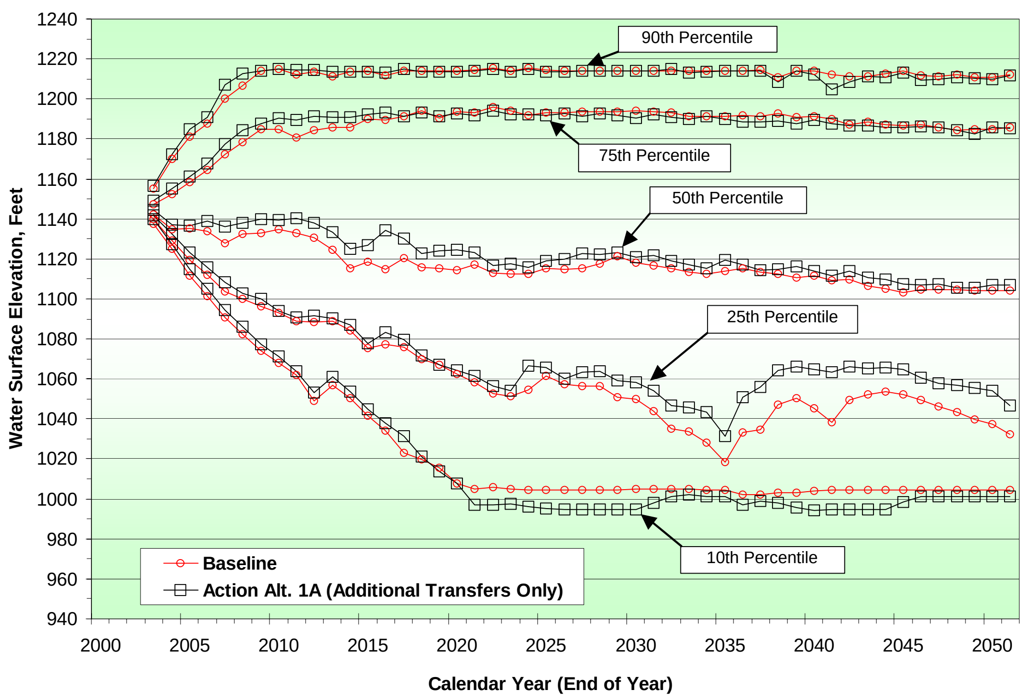
J.B.2 Analysis Results

A summary of the results for each incremental analysis follows.

J.B.2.1 Action Alternative 1A (Future Water Transfers Only)

Figure J.B-1 presents a comparison of the 90th, 75th, 50th, 25th, and 10th percentile lines obtained for the Baseline and the Action Alternative 1A scenarios. This action alternative scenario modeled only the additional water transfers.

Figure J.B-1
Lake Mead End-of-December Water Elevations—
Comparison of Baseline to Action Alternative No. 1A Scenarios
(Action Alternative No. 1A Includes Additional Transfers Only)
90th, 75th, 50th, 25th, and 10th Percentile Values



The median Lake Mead elevations under the Baseline and Action Alternative1A scenarios decline throughout the period of analysis due to increasing Upper Basin depletions. Figure J.B-1 also illustrates that the median elevations are higher under Action Alternative 1A when compared to the Baseline through 2051, with a maximum difference of 19.6 feet in year 2016. This effect is explained by the positive effect that the water transfers have on Lake Mead content and water surface levels. This positive effect is due to the fact that less water is delivered from Lake Mead when Surplus conditions are determined (i.e., the need for surplus water is diminished since that water has already been provided by the transfers).

It should be noted that under Baseline, future Lake Mead water levels at the 90th and 10th percentiles would likely be temporary and the water levels are expected to fluctuate between them in response to multi-year variations in basin runoff conditions. The same would apply under the Action Alternative 1A scenario. The numeric differences between the 90th, 75th, 50th, 25th, and 10th percentile values of the Action Alternative No. 1A and those of the Baseline are presented in Table J.B-1. The values presented in this table after 2025 are for every five years.

Table J.B-1. Lake Mead End-of-December Water Elevations Annual Differences Between Baseline and Action Alternative No. 1A Scenarios (Action Alternative No. 1A—Includes Additional Transfers Only) 90th, 75th, 50th, 25th, and 10th Percentile Values

	Difference in Water Surface Elevations (feet)				
Year	90th Percentile	75th Percentile	50th Percentile	25th Percentile	10th Percentile
2003	1.0	2.0	2.1	2.0	2.2
2004	2.4	2.6	2.4	3.0	2.4
2005	3.4	3.1	1.8	3.6	3.5
2006	3.5	3.2	5.1	3.8	3.7
2007	6.8	5.1	8.4	4.5	3.5
2008	5.7	6.0	5.6	2.9	3.6
2009	0.0	2.7	6.5	3.4	3.4
2010	-0.1	5.4	4.7	1.2	3.4
2011	2.3	8.6	7.4	1.7	1.9
2012	0.5	6.7	7.4	3.7	4.1
2013	2.2	5.3	8.7	1.4	4.3
2014	-0.2	5.4	9.8	2.7	3.3
2015	-0.1	2.2	8.2	2.0	2.8
2016	1.6	3.7	19.6	6.3	3.8
2017	0.8	0.2	10.1	3.7	8.4
2018	-0.2	-1.1	7.0	1.7	1.8
2019	-0.2	1.3	8.7	0.0	-2.1
2020	-0.2	-0.8	10.3	2.0	-0.1
2021	-0.2	-1.4	6.0	3.4	-8.1
2022	-0.3	-1.8	4.0	3.7	-8.6
2023	-0.3	-1.7	4.9	2.6	-7.5
2024	-0.5	0.7	3.3	12.0	-8.2
2025	-0.6	-1.1	3.7	4.1	-9.1
2030	-0.3	-3.8	2.7	8.3	-10.3
2035	-0.3	-1.5	5.5	12.8	-3.3
2040	-1.5	-1.7	2.4	19.5	-9.8
2045	-1.1	-1.0	4.1	12.5	-5.8
2050	-0.9	1.1	2.8	16.4	-3.5

Table J.B-2 provides more information on the general differences between the 90th, 75th, 50th, 25th, and 10th percentile lines of the Baseline and Action Alternative1A (same data

presented in Figure J.B-1). Specifically, this table presents the average of the differences between the 90th, 75th, 50th, 25th, and 10th percentile lines of the two modeled scenarios for selected periods (2003–2015, 2016–2025, and 2026–2051).

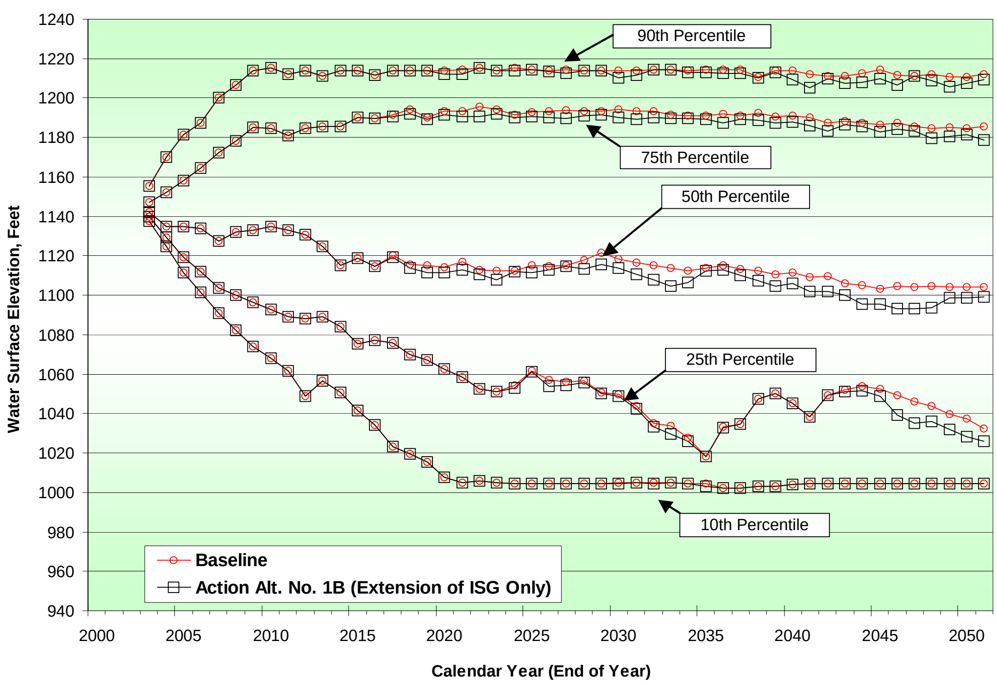
Table J.B-2. Lake Mead End-of-December Water Elevations Average Differences Between Baseline and Action Alternative No. 1A Scenarios (Action Alternative No. 1A—Includes Additional Transfers Only) 90th, 75th, 50th, 25th, and 10th Percentile Values

Year	Average Difference in Water Surface Elevations (feet)				
	90th Percentile	75th Percentile	50th Percentile	25th Percentile	10th Percentile
2003–2015	2.1	4.5	6.0	2.8	3.2
2016–2025	0.0	-0.2	7.8	3.9	-3.0
2026–2051	-1.0	-1.6	3.5	13.4	-6.4

J.B.2.2 Action Alternative 1B (Extension of the Effective Period of ISG Only)

Figure J.B-2 presents a comparison of the 90th, 75th, 50th, 25th, and 10th percentile lines obtained for the Baseline and the Action Alternative No. 1B scenarios. This action alternative scenario modeled only the extension of the effective period of ISG through 2051.

Figure J.B-2
Lake Mead End-of-December Water Elevations—
Comparison of Baseline to Action Alternative No. 1B Scenarios
(Action Alternative No. 1B Includes Extension of Interim Surplus Guidelines Only)
90th, 75th, 50th, 25th, and 10th Percentile Values



The median elevations are identical under the Action Alternative 1B when compared to Baseline through the original ISG period of 2003 through 2016. Beginning in 2017, the median elevations are lower under Action Alternative 1B when compared to the Baseline through 2051, with a maximum difference of 7.4 feet in year 2045.

The 90th, 75th, 50th, 25th, and 10th percentile values of the action alternative scenarios are compared to those of the Baseline in Table J.B-3. The values presented in this table after 2025 are for every five years.

Table J.B-3. Lake Mead End-of-December Water Elevations Yearly Differences Between Baseline and Action Alternative No. 1B Scenarios (Action Alternative No. 1B.—Includes Extension of Interim Surplus Guidelines Only) 90th, 75th, 50th, 25th, and 10th Percentile Values

	Difference in Water Surface Elevations (feet)				
Year	90th Percentile	75th Percentile	50th Percentile	25th Percentile	10th Percentile
2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0	0.0
2014	0.0	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0	0.0
2016	0.0	0.0	0.0	0.0	0.0
2017	0.0	-0.5	-1.0	0.0	0.0
2018	0.0	-1.9	-2.0	0.0	0.0
2019	0.2	-0.9	-4.0	0.0	0.0
2020	-1.9	-1.9	-3.0	0.0	0.0
2021	-2.3	-3.0	-4.2	0.0	0.0
2022	0.0	-5.3	-2.2	0.0	0.0
2023	0.0	-2.1	-4.5	0.0	0.0
2024	-1.3	-1.6	-0.6	-1.6	0.0
2025	0.3	-2.5	-3.7	-0.5	0.0
2030	-4.0	-4.0	-4.5	-1.3	-0.5
2035	-1.3	-1.8	-1.5	0.0	-1.5
2040	-4.6	-3.1	-5.8	0.0	0.0
2045	-4.5	-3.6	-7.4	-3.5	0.0
2050	-3.1	-3.2	-5.8	-9.2	0.0

Table J.B-4 provides more information on the general differences between the 90th, 75th, 50th, 25th, and 10th percentile lines of the Baseline and Action Alternative 1B (same data

presented in Figure J.B-2). Specifically, this table presents the average of the differences between the 90th, 75th, 50th, 25th, and 10th percentile lines of the two modeled scenarios for selected periods (2003–2015, 2016–2025, and 2026–2051).

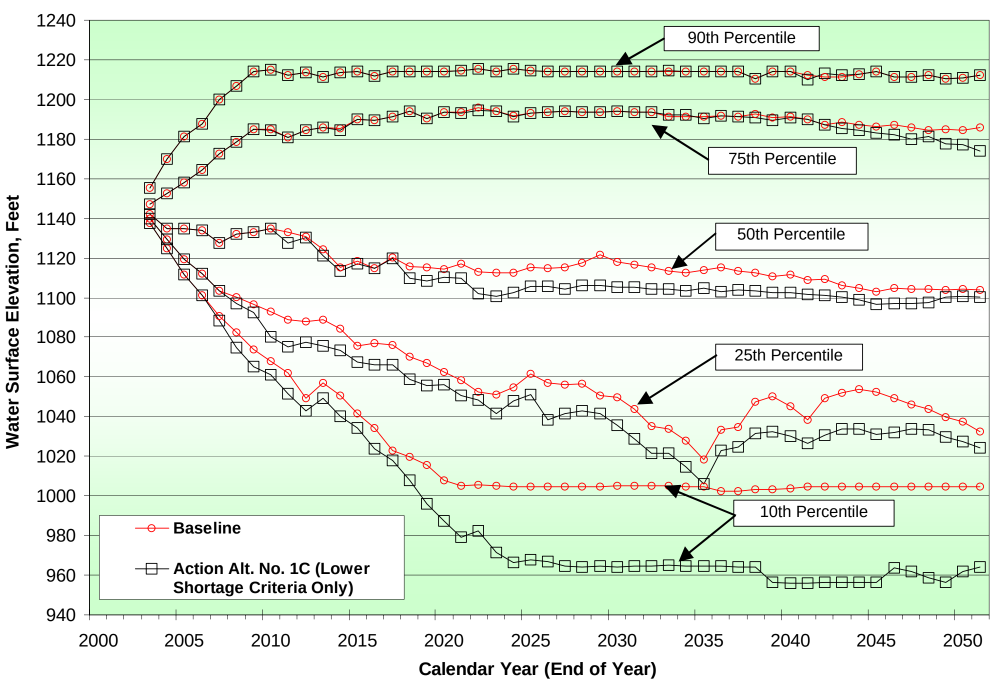
Table J.B-4. Lake Mead End-of-December Water Elevations Average Differences Between Baseline and Action Alternative No. 1B Scenarios (Action Alternative No. 1B—Includes Extension of Interim Surplus Guidelines Only) 90th, 75th, 50th, 25th, and 10th Percentile Values

Year	Average Difference in Water Surface Elevations (feet)				
	90th Percentile	75th Percentile	50th Percentile	25th Percentile	10th Percentile
2003–2015	0.0	0.0	0.0	0.0	0.0
2016–2025	-0.5	-2.0	-2.5	-0.2	0.0
2026–2051	-2.4	-3.3	-6.0	-3.0	-0.1

J.B.2.3 Action Alternative 1C (Lower Lake Mead Shortage Criteria)

Figure J.B-3 presents a comparison of the 90th, 75th, 50th, 25th, and 10th percentile lines obtained for the Baseline and the Action Alternative 1C scenarios. This action alternative scenario modeled only the lower Lake Mead Shortage protection.

Figure J.B-3
Lake Mead End-of-December Water Elevations—
Comparison of Baseline to Action Alternative No. 1C Scenarios
(Action Alt. No. 1C Includes Lower Shortage Criteria Only)
90th, 75th, 50th, 25th, and 10th Percentile Values



The median elevations are identical under Action Alternative 1C when compared to the Baseline through 2010. Beginning in 2011, the median elevations are lower under Action Alternative 1C, with a maximum difference of 12.8 feet in year 2030.

The 90th, 75th, 50th, 25th, and 10th percentile values of the action alternative scenarios are compared to those of the Baseline in Table J.B-5. The values presented in this table after 2025 are for every five years.

Table J.B-5. Lake Mead End-of-December Water Elevations Annual Differences Between Baseline and Action Alternative No. 1C Scenarios (Action Alternative No. 1C—Includes Lower Shortage Criteria Only) 90th, 75th, 50th, 25th, and 10th Percentile Values

	Difference in Water Surface Elevations (feet)				
Year	90th Percentile	75th Percentile	50th Percentile	25th Percentile	10th Percentile
2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	-2.6
2008	0.0	0.0	0.0	-3.2	-7.7
2009	0.0	0.0	0.0	-3.8	-8.8
2010	0.0	-0.5	0.0	-12.6	-6.9
2011	0.0	0.0	-5.1	-13.7	-10.3
2012	0.0	0.0	-0.4	-10.8	-6.1
2013	0.0	0.0	-3.5	-13.3	-7.4
2014	0.0	-1.1	-2.0	-10.8	-10.2
2015	0.0	0.0	-1.4	-8.0	-7.5
2016	0.0	0.0	0.0	-10.9	-10.3
2017	0.0	0.0	-0.4	-9.9	-5.4
2018	0.0	0.0	-5.8	-11.3	-11.8
2019	0.0	0.0	-6.9	-11.3	-19.8
2020	0.0	0.0	-4.0	-6.5	-20.4
2021	0.0	-0.1	-7.1	-7.7	-25.7
2022	0.0	-1.4	-10.8	-4.3	-23.2
2023	0.0	0.0	-11.9	-9.9	-33.4
2024	0.0	-0.4	-10.1	-6.7	-38.0
2025	0.0	0.0	-9.5	-10.7	-36.7
2030	0.0	-0.2	-12.8	-14.5	-40.9
2035	0.0	-0.8	-8.8	-12.3	-40.1
2040	0.0	-0.2	-9.3	-15.3	-48.1
2045	0.0	-3.4	-6.4	-21.2	-47.9
2050	0.0	-7.3	-3.6	-10.0	-43.0

Table J.B-6 provides more information on the general differences between the 90th, 75th, 50th, 25th, and 10th percentile lines of the Baseline and Action Alternative 1C (same data

presented in Figure J.B-3). Specifically, this table presents the average of the differences between the 90th, 75th, 50th, 25th, and 10th percentile lines of the two modeled scenarios for selected periods (2003–2015, 2016–2025, and 2026–2051).

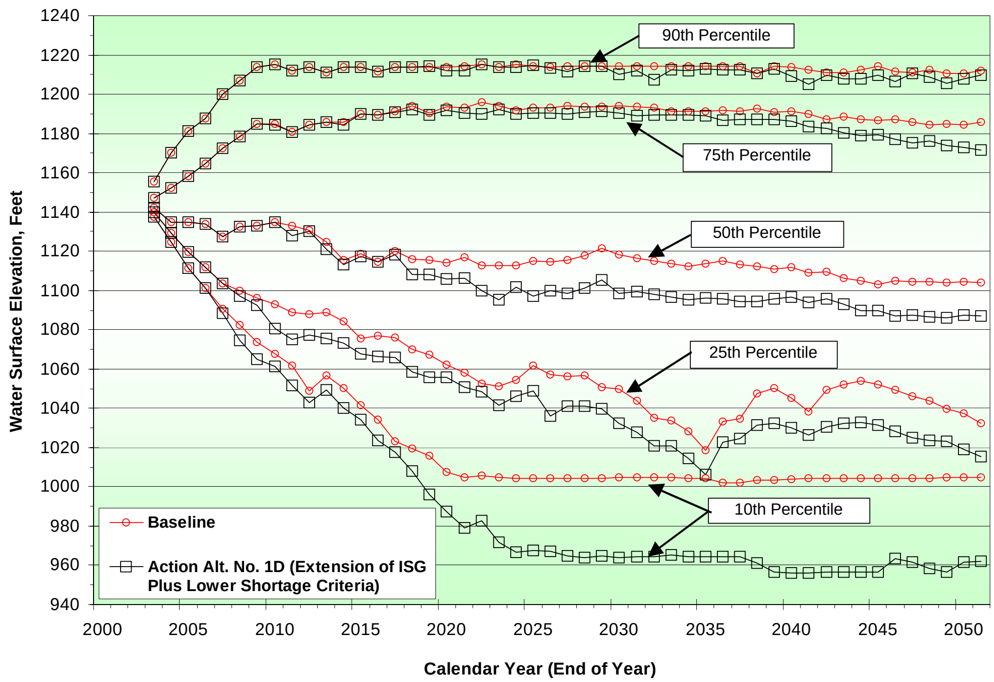
Table J.B-6. Lake Mead End-of-December Water Elevations Average Differences Between Baseline and Action Alternative No. 1C Scenarios (Action Alternative No. 1C—Includes Lower Shortage Criteria Only) 90th, 75th, 50th, 25th, and 10th Percentile Values

Year	Average Difference in Water Surface Elevations (feet)				
	90th Percentile	75th Percentile	50th Percentile	25th Percentile	10th Percentile
2003–2015	0.0	-0.1	-1.0	-5.9	-5.2
2016–2025	0.0	-0.2	-6.7	-8.9	-22.5
2026–2051	0.0	-2.1	-8.6	-14.1	-42.7

J.B.2.4 Action Alternative 1D (Extended ISG Period Plus Lower Lake Mead Shortage Criteria)

Figure J.B-4 presents a comparison of the 90th, 75th, 50th, 25th, and 10th percentile lines obtained for the Baseline and the Action Alternative 1D scenarios. This action alternative scenario modeled both the extension of the effective period of ISG through 2051 and the lower Lake Mead Shortage protection.

Figure J.B-4
Lake Mead End-of-December Water Elevations—
Comparison of Baseline to Action Alternative No. 1D Scenarios
(Action Alt. No. 1D Includes Extension of ISG and Lower Shortage Criteria)
90th, 75th, 50th, 25th, and 10th Percentile Values



The median elevations are identical under Action Alternative 1D when compared to the Baseline through 2010. Beginning in 2011, the median elevations are lower under Action Alternative 1D, with a maximum difference of 19.8 feet in year 2030.

The 90th, 75th, 50th, 25th, and 10th percentile values of the action alternative scenario are compared to those of the Baseline in Table J.B-7. The values presented in this table after 2025 are for every five years.

Table J.B-7. Lake Mead End-of-December Water Elevations Annual Differences Between Baseline and Action Alternative No. 1D Scenarios (Action Alternative 1D—Includes Extension of Interim Surplus Guidelines and Lower Shortage Criteria) 90th, 75th, 50th, 25th, and 10th Percentile Values

	Difference in Water Surface Elevations (feet)				
Year	90th Percentile	75th Percentile	50th Percentile	25th Percentile	10th Percentile
2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	-2.6
2008	0.0	0.0	0.0	-3.2	-7.7
2009	0.0	0.0	0.0	-3.8	-8.8
2010	0.0	-0.5	0.0	-12.6	-6.9
2011	0.0	0.0	-5.1	-13.7	-10.3
2012	0.0	0.0	-0.4	-10.8	-6.1
2013	0.0	0.0	-3.5	-13.3	-7.4
2014	0.0	-1.1	-2.0	-10.8	-10.2
2015	0.0	0.0	-1.4	-8.0	-7.5
2016	0.0	0.0	0.0	-10.9	-10.3
2017	0.0	-0.5	-2.1	-9.9	-5.4
2018	0.0	-1.9	-7.9	-11.3	-11.8
2019	0.2	-0.9	-7.2	-11.3	-19.8
2020	-1.9	-1.9	-8.4	-6.5	-20.4
2021	-2.3	-3.0	-10.7	-7.7	-25.7
2022	0.0	-5.9	-13.1	-4.3	-23.2
2023	0.0	-2.1	-17.3	-9.9	-33.4
2024	-1.3	-1.6	-10.8	-8.4	-38.0
2025	0.3	-2.5	-18.1	-12.9	-36.7
2030	-4.0	-4.0	-19.8	-17.4	-40.9
2035	-1.3	-2.4	-17.7	-12.3	-40.1
2040	-4.6	-5.0	-14.8	-15.3	-48.1
2045	-4.5	-6.9	-13.5	-20.9	-47.9
2050	-3.1	-11.5	-16.8	-18.2	-43.0

Table J.B-8 provides more information on the general differences between the 90th, 75th, 50th, 25th, and 10th percentile lines of the Baseline and Action Alternative 1D (same data

presented in Figure J.B-4). Specifically, this table presents the average of the differences between the 90th, 75th, 50th, 25th, and 10th percentile lines of the two modeled scenarios for selected periods (2003–2015, 2016–2025, and 2026–2051).

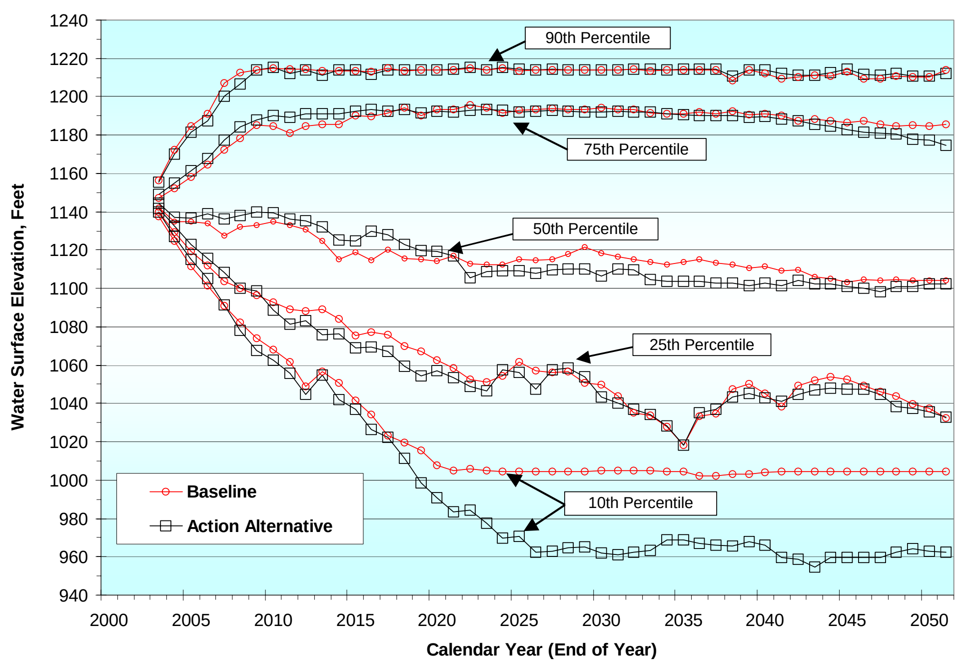
Table J.B-8. Lake Mead End-of-December Water Elevations Average Differences Between Baseline and Action Alternative No. 1D Scenarios (Action Alternative 1D—Includes Extension of ISG and Lower Shortage Criteria) 90th, 75th, 50th, 25th, and 10th Percentile Values

Year	Average Difference in Water Surface Elevations (feet)				
	90th Percentile	75th Percentile	50th Percentile	25th Percentile	10th Percentile
2003–2015	0.0	-0.1	-1.0	-5.9	-5.2
2016–2025	-0.5	-2.0	-9.6	-9.3	-22.5
2026–2051	-2.8	-5.9	-16.5	-16.4	-42.9

J.B.2.5 Action Alternative (Combined effects of Three Actions)

Figure J.B-5 presents a comparison of the 90th, 75th, 50th, 25th, and 10th percentile lines for the Baseline and the Action Alternative scenarios. This action alternative scenario modeled all three changes: future water transfers, the extension of the effective period of ISG through 2051 and the Lower Lake Mead Shortage protection. This is the alternative analyzed in Section J.6.

Figure J.B-5
Lake Mead End-of-December Water Elevations—
Comparison of Baseline to Action Alternative (Base Case) Scenarios
(Base Case Action Alternative Includes All Three Actions)
90th, 75th, 50th, 25th, and 10th Percentile Values



The median Lake Mead elevations under the Baseline and Action Alternative scenarios decline throughout the period of analysis due to increasing Upper Basin depletions. Figure J.B-5 also illustrates that the median elevations are higher under the Action Alternative when compared to the Baseline throughout the period 2003 through 2021, with a maximum difference of 15.2 feet in 2016. Beginning in 2022, the median elevations are lower under the Action Alternative, with a maximum difference of 11.7 feet in year 2030.

The 90th, 75th, 50th, 25th, and 10th percentile values of the action alternative scenarios are compared to those of the Baseline in Table J.B-9. The values presented in this table after 2025 are for every five years.

Table J.B-9. Lake Mead End-of-December Water Elevations Annual Differences Between Baseline and Action Alternative Scenarios (Base Case Action Alternative—Includes All Three Actions) 90th, 75th, 50th, 25th, and 10th Percentile Values

	Difference in Water Surface Elevations (feet)				
Year	90th Percentile	75th Percentile	50th Percentile	25th Percentile	10th Percentile
2003	1.0	2.0	2.1	2.0	2.2
2004	2.4	2.6	2.4	3.0	2.4
2005	3.4	3.1	1.8	3.6	3.5
2006	3.5	3.2	5.1	3.8	3.7
2007	6.8	5.1	8.4	4.5	0.8
2008	5.7	6.0	5.6	0.2	-4.2
2009	0.0	2.7	6.5	2.2	-6.2
2010	-0.1	5.4	4.7	-4.5	-5.4
2011	2.3	8.6	3.4	-7.4	-6.3
2012	0.5	6.7	4.6	-4.9	-4.2
2013	2.2	5.3	7.8	-13.1	-2.2
2014	-0.2	5.4	9.8	-8.1	-8.4
2015	-0.2	2.2	6.3	-6.8	-4.9
2016	1.6	3.7	15.2	-7.5	-7.6
2017	0.8	1.3	7.9	-8.9	-0.7
2018	-0.2	-0.7	6.9	-10.7	-8.0
2019	-0.1	1.2	4.2	-12.8	-17.0
2020	-0.2	-0.9	5.1	-5.3	-16.7
2021	-0.2	-1.5	0.2	-4.8	-21.3
2022	-0.3	-3.0	-7.5	-3.9	-21.3
2023	-0.3	-0.9	-3.9	-4.9	-27.6
2024	-0.3	1.2	-3.5	3.2	-34.6
2025	-0.6	-0.9	-5.7	-5.6	-34.0
2030	-0.3	-2.1	-11.7	-6.4	-42.9
2035	-0.3	-0.8	-10.1	-0.1	-35.6
2040	-1.6	-1.5	-8.6	-2.3	-38.0
2045	-1.2	-3.6	-2.3	-4.8	-45.0
2050	-0.5	-7.3	-1.9	-2.0	-42.0

Table J.B-10 provides more information on the general differences between the 90th, 75th, 50th, 25th, and 10th percentile lines of the Baseline and Action Alternative (same data presented in Figure J.B-5). Specifically, this table presents the average of the differences between the 90th, 75th, 50th, 25th, and 10th percentile lines of the two modeled scenarios for selected periods (2003–2015, 2016–2025, and 2026–2051).

Table J.B-10. Lake Mead End-of-December Water Elevations Average Differences Between Baseline and Action Alternative Scenarios (Base Case Action Alternative—Includes All Three Actions) 90th, 75th, 50th, 25th, and 10th Percentile Values

Year	Average Difference in Water Surface Elevations (feet)				
	90th Percentile	75th Percentile	50th Percentile	25th Percentile	10th Percentile
2003–2015	2.1	4.5	5.3	-2.0	-2.2
2016–2025	0.0	0.0	1.9	-6.1	-18.9
2026–2051	-0.8	-2.6	-6.7	-1.9	-41.3

Attachment C

Initial Reservoir Conditions

Attachment C
Initial Reservoir Conditions

The Model was initialized with the following actual data, as of midnight, December 31, 2002.

Reservoir	Elevation (feet)	Storage (thousand acre-feet)
Fontenelle	6,487.79	213
Flaming Gorge	6,009.71	2,632
Taylor Park	9,288.42	41
Blue Mesa	7,444.59	283
Morrow Point	7,150.72	110
Crystal	6,742.41	14
Navajo	6,010.55	827
Powell	3,620.10	13,774
Mead	1,152.13	16,718
Mohave	642.27	1,679
Havasu	446.21	547
Total system storage	**Not Applicable**	**36,838**

Attachment D

Analyses of Hydrologic Impacts to the River Corridor (Reaches 3–5)

Attachment D

Analyses of Hydrologic Impacts to the River Corridor (Reaches 3–5)

As discussed in Section J.6.2, flows in the river below Davis Dam and Parker Dam were modeled for four operational scenarios representing four mean daily releases and their corresponding hourly hydrographs: Average Annual, and Monthly for April, August, and December. These data are referred to as “Reference.” Another four hydrographs were analyzed with the appropriate flow reductions applied to the releases from each dam. These data are referred to as “Reduced Release.” The Average Annual analyses for Davis Dam and Parker Dam were presented in Section J.6.2. The results of the Monthly analyses are presented for each dam in this attachment.

Tale J.D-1. Effect of Davis Dam Release Reduction (860 kaf Reduction) on River Stage at Different River Locations, Monthly Analysis for April, Reference Mean Daily Flow of 15,845 cfs and Reduced Mean Daily Flow of 14,199 cfs

	Reference Flow		Reduced Release		Change	
Location (River Mile)	Minimum Hourly Flow (cfs)	Stage (feet)	Minimum Hourly Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)
Mean Daily Release	15,845	NA	14,199	NA	-1,646	NA
270.5	9,610	496.58	4,936	494.49	-4,674	-2.09
267.2	9,610	489.48	4,936	487.15	-4,674	-2.33
262.9	9,610	477.13	4,936	474.10	-4,674	-3.03
255.1	9,610	468.53	4,936	465.50	-4,674	-3.02
259.6	9,610	473.61	4,936	470.79	-4,674	-2.82
248.9	12,465	464.09	9,331	462.42	-3,134	-1.67
243.9	12,465	458.56	9,331	456.75	-3,134	-1.82
240.8	12,465	456.77	9,331	455.08	-3,134	-1.69
237.6	12,465	454.03	9,331	452.50	-3,134	-1.53
234.7	13,146	452.71	10,040	451.37	-3,106	-1.34
229.8	13,146	450.25	10,040	449.03	-3,106	-1.22
225.0	13,146	448.95	10,040	448.04	-3,106	-0.92
220.2	13,146	447.64	10,040	447.09	-3,106	-0.55

Figure J.D-1
Comparison of Davis Dam Release and River Flow near Topock Marsh Inlet
April—Reference to Reduced Flow (860 kaf Release Reduction)

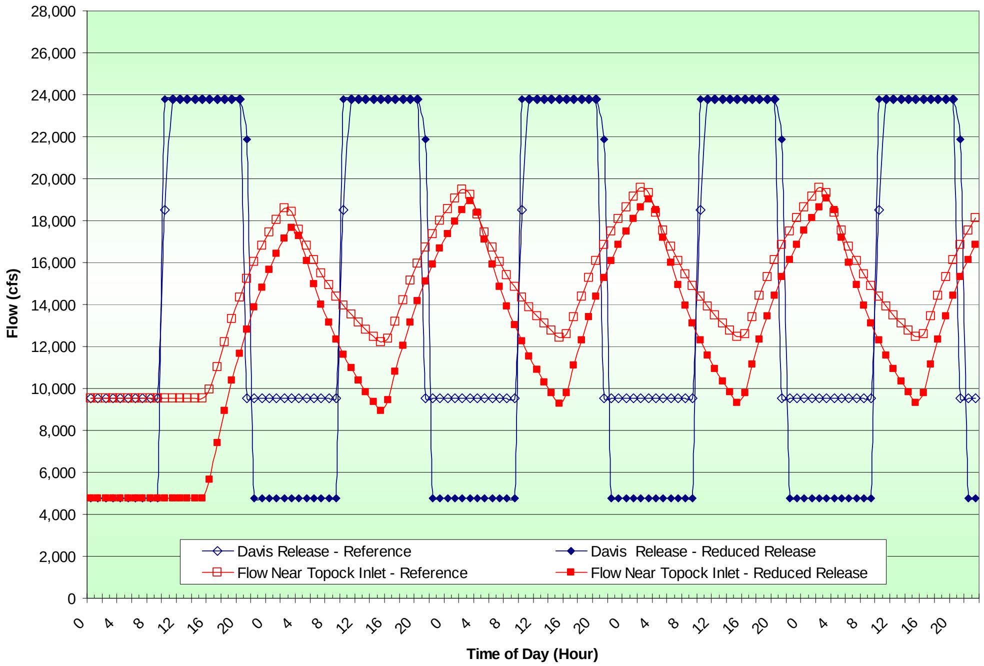


Figure J.D-2
Comparison of River Stage near Topock Marsh Inlet
April—Reference to Reduced Flow (860 kaf Release Reduction)

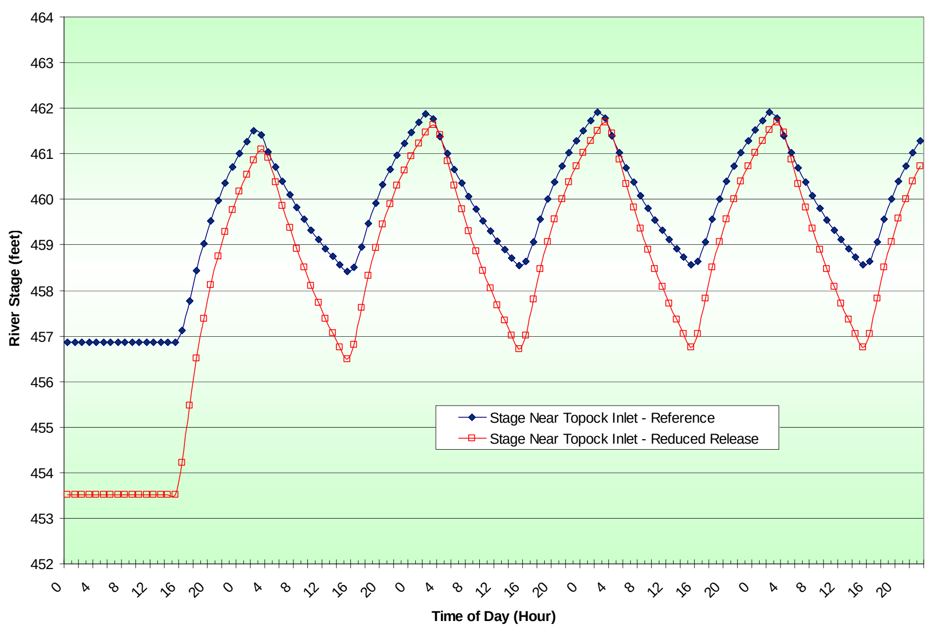


Table J.D-2. Effect of Davis Dam Release Reduction (860 kaf Reduction) on River Stage at Different River Locations, Monthly Analysis for August, Reference Mean Daily Flow of 14,422 cfs and Reduced Mean Daily Flow of 13,062 cfs

	Reference Flow		Reduced Release		Change	
Location (River Mile)	Minimum Hourly Flow (cfs)	Stage (feet)	Minimum Hour Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)
Mean Daily Release	14,422	NA	13,062	NA	-1,360	NA
270.5	5,033	494.54	4,881	494.46	-152	-0.08
267.2	5,033	487.21	4,881	487.12	-152	-0.09
262.9	5,033	474.17	4,881	474.05	-152	-0.11
255.1	5,033	465.58	4,881	465.46	-152	-0.11
259.6	5,033	470.85	4,881	470.75	-152	-0.10
248.9	9,592	462.56	8,651	462.01	-941	-0.55
243.9	9,592	456.91	8,651	456.32	-941	-0.59
240.8	9,592	455.23	8,651	454.67	-941	-0.56
237.6	9,592	452.64	8,651	452.14	-941	-0.50
234.7	10,525	451.59	9,439	451.10	-1,086	-0.49
229.8	10,525	449.22	9,439	448.80	-1,086	-0.42
225.0	10,525	448.18	9,439	447.87	-1,086	-0.31
220.2	10,525	447.17	9,439	446.99	-1,086	-0.18

Figure J.D-3
Comparison of Davis Dam Release and River Flow near Topock Marsh Inlet
August—Reference to Reduced Flow (860 kaf Release Reduction)

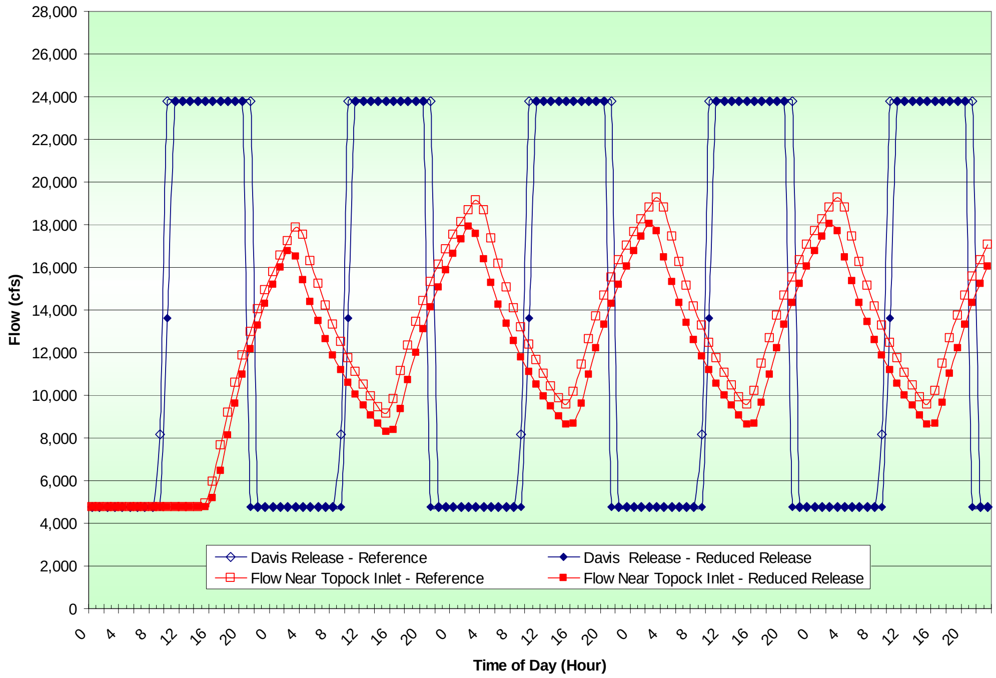


Figure J.D-4
Comparison of River Stage near Topock Marsh Inlet
August—Reference to Reduced Flow (860 kaf Release Reduction)

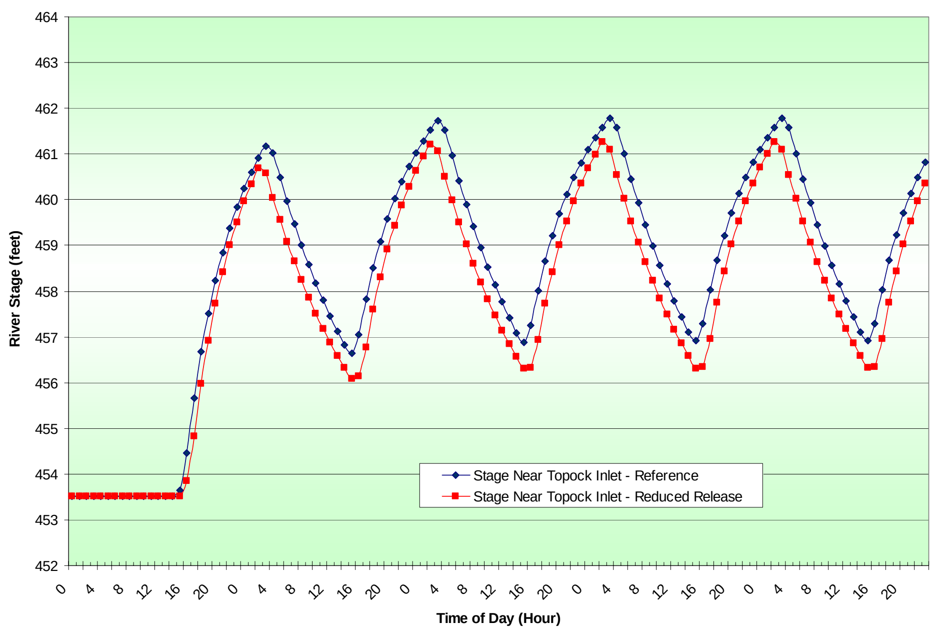


Table J.D-3. Effect of Davis Dam Release Reduction (860 kaf Reduction) on River Stage at Different River Locations, Monthly Analysis for December, Reference Mean Daily Flow of 8,342 cfs and Reduced Mean Daily Flow of 7,752 cfs

	Reference Flow		Reduced Release		Change	
Location (River Mile)	Minimum Hourly Flow (cfs)	Stage (feet)	Minimum Hourly Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)
Mean Daily Release	8,342	NA	7,752	NA	-590	NA
270.5	4,787	494.41	4,775	494.40	-12	-0.01
267.2	4,787	487.06	4,775	487.06	-12	-0.01
262.9	4,787	473.98	4,775	473.97	-12	-0.01
255.1	4,787	465.39	4,775	465.38	-12	-0.01
259.6	4,787	470.69	4,775	470.68	-12	-0.01
248.9	6,226	460.45	5,887	460.22	-339	-0.24
243.9	6,226	454.64	5,887	454.39	-339	-0.25
240.8	6,226	453.09	5,887	452.85	-339	-0.24
237.6	6,226	450.75	5,887	450.54	-339	-0.21
234.7	6,683	449.76	6,269	449.55	-414	-0.21
229.8	6,683	447.76	6,269	447.61	-414	-0.15
225.0	6,683	447.12	6,269	447.02	-414	-0.10
220.2	6,683	446.56	6,269	446.50	-414	-0.06

Figure J.D-5
Comparison of Davis Dam Release and River Flow near Topock Marsh Inlet
December—Reference to Reduced Flow (860 kaf Release Reduction)

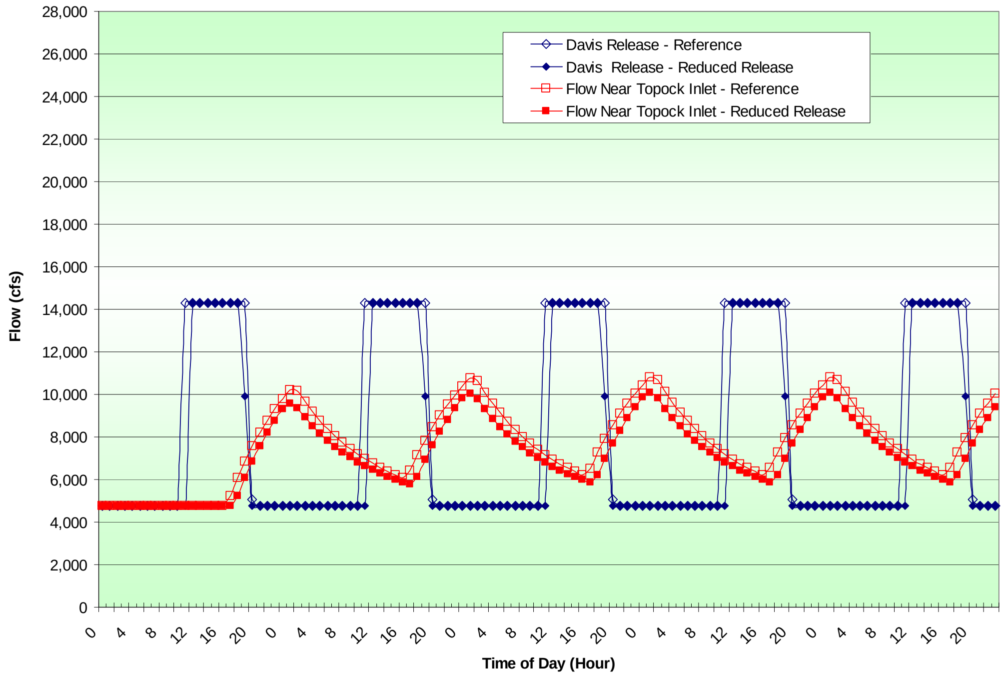


Figure J.D-6
Comparison of River Stage near Topock Marsh Inlet
December—Reference to Reduced Flow (860 kaf Release Reduction)

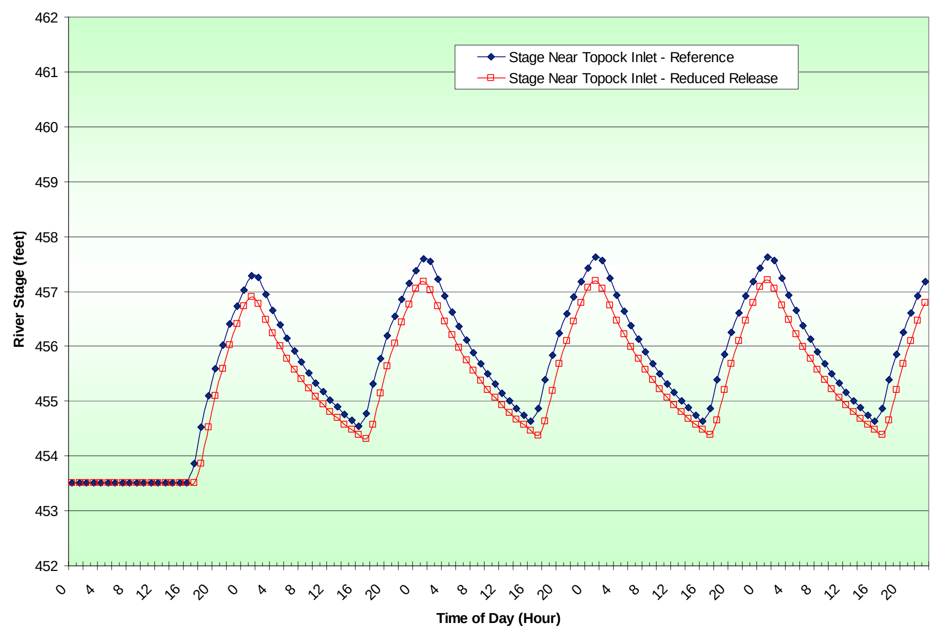


Table J.D-4. Effect of Parker Dam Release Reduction (1.574 maf Reduction) on River Stage at Different River Locations, Monthly Analysis for April, Reference Mean Daily Flow of 14,234 cfs and Reduced Mean Daily Flow of 11,221 cfs

	Reference Flow		Reduced Release		Change	
Location (River Mile)	Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)
Mean Daily Release	14,234	NA	11,221	NA	-3,013	NA
171.3	10,437	335.05	5,613	332.59	-4,824	-2.46
167.6	10,437	328.67	5,613	326.02	-4,824	-2.65
160.9	10,437	317.09	5,613	314.51	-4,824	-2.58
149.5	10,437	299.89	5,613	297.30	-4,824	-2.60
146.9	10,437	296.24	5,613	294.23	-4,824	-2.01
135.8	10,437	283.97	5,613	283.66	-4,824	-0.31
119.7	10,004	249.29	6,806	247.75	-3,198	-1.54
116.5	10,004	243.28	6,806	241.25	-3,198	-2.03
114.6	10,004	240.75	6,806	238.87	-3,198	-1.87
109.1	10,004	232.23	6,806	230.34	-3,198	-1.90
103.1	10,004	225.61	6,806	223.96	-3,198	-1.65
96.7	10,004	217.27	6,806	215.35	-3,198	-1.92
86.1	10,970	208.09	7,898	206.66	-3,072	-1.43
80.4	10,970	202.97	7,898	201.74	-3,072	-1.23
72.2	10,970	195.17	7,898	193.84	-3,072	-1.32
70.3	10,970	194.13	7,898	192.80	-3,072	-1.34
66.1	10,970	190.14	7,898	188.75	-3,072	-1.39
56.0	11,547	184.88	8,512	183.80	-3,035	-1.08
53.6	11,547	181.62	8,512	180.89	-3,035	-0.73
50.8	11,547	179.81	8,512	179.68	-3,035	-0.13

Figure J.D-7
Comparison of Parker Dam Release and River Flow near Taylor Ferry
April—Reference to Reduced Flow (1.574 maf Release Reduction)

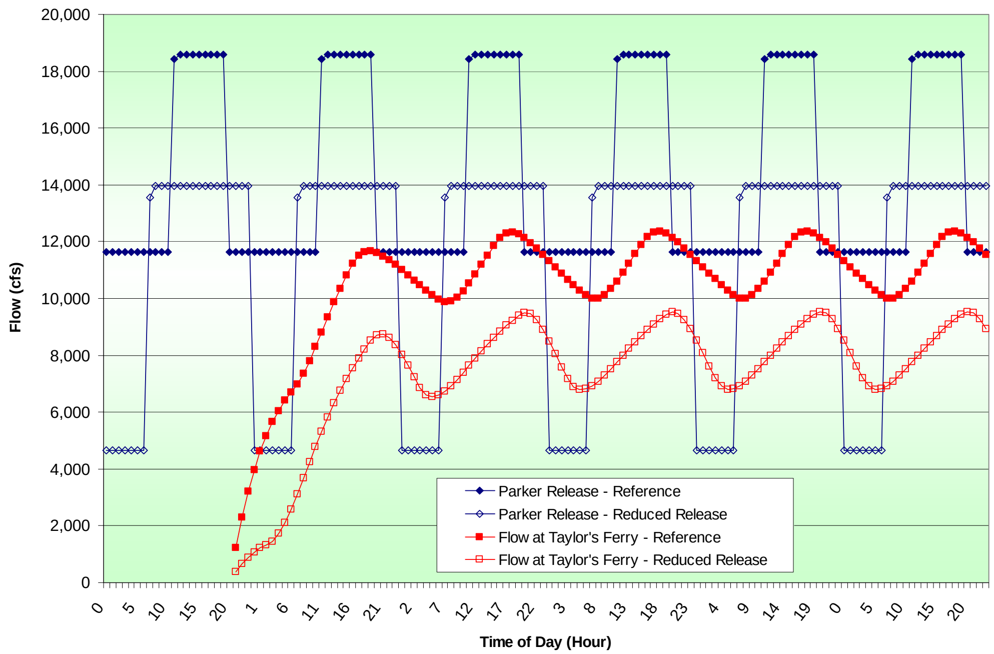


Figure J.D-8
Comparison of River Stage near Taylor Ferry
April—Reference to Reduced Flow (1.574 maf Release Reduction)

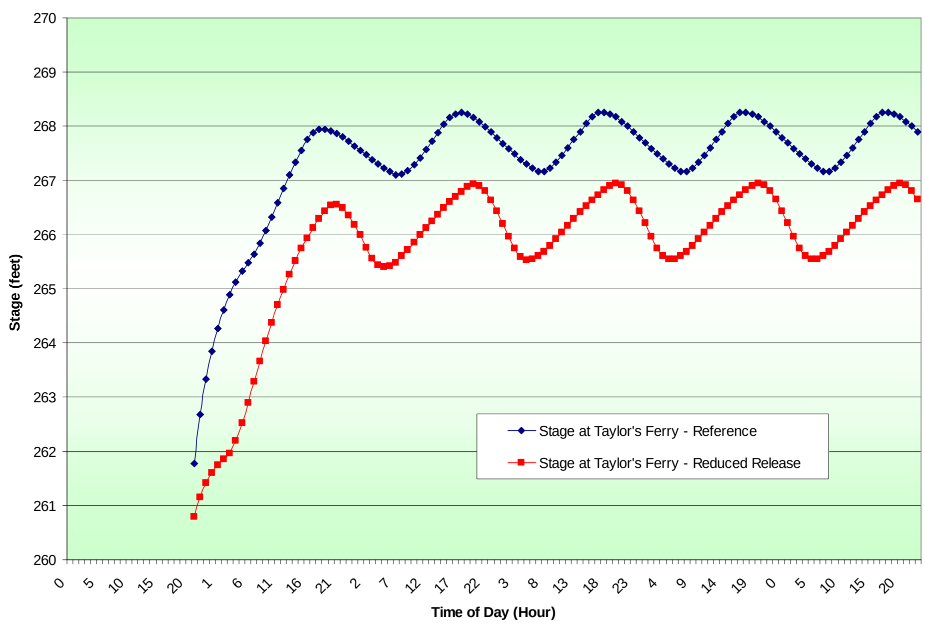


Table J.D-5. Effect of Parker Dam Release Reduction (1.574 maf Reduction) on River Stage at Different River Locations, Monthly Analysis for August, Reference Mean Daily Flow of 10,818 cfs and Reduced Mean Daily Flow of 8,331 cfs

	Reference Flow		Reduced Release		Change	
Location (River Mile)	Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)
Mean Daily Release	10,818	NA	8,331	NA	-2,487	NA
171.3	5,412	332.48	5,051	332.27	-361	-0.21
167.6	5,412	325.89	5,051	325.67	-361	-0.23
160.9	5,412	314.38	5,051	314.15	-361	-0.23
149.5	5,412	297.16	5,051	296.91	-361	-0.25
146.9	5,412	294.13	5,051	293.93	-361	-0.19
135.8	5,412	283.65	5,051	283.63	-361	-0.02
119.7	6,853	247.78	5,302	246.90	-1,551	-0.87
116.5	6,853	241.29	5,302	240.12	-1,551	-1.16
114.6	6,853	238.90	5,302	237.81	-1,551	-1.09
109.1	6,853	230.37	5,302	229.29	-1,551	-1.07
103.1	6,853	223.99	5,302	223.08	-1,551	-0.91
96.7	6,853	215.38	5,302	214.32	-1,551	-1.06
86.1	8,264	206.85	6,387	205.81	-1,877	-1.04
80.4	8,264	201.90	6,387	201.04	-1,877	-0.86
72.2	8,264	194.01	6,387	193.11	-1,877	-0.91
70.3	8,264	192.97	6,387	192.05	-1,877	-0.92
66.1	8,264	188.93	6,387	188.02	-1,877	-0.91
56.0	8,930	183.96	6,619	183.02	-2,311	-0.94
53.6	8,930	180.99	6,619	180.47	-2,311	-0.53
50.8	8,930	179.70	6,619	179.62	-2,311	-0.08

Figure J.D-9
Comparison of Parker Dam Release and River Flow near Taylor Ferry
August—Reference to Reduced Flow (1.574 maf Release Reduction)

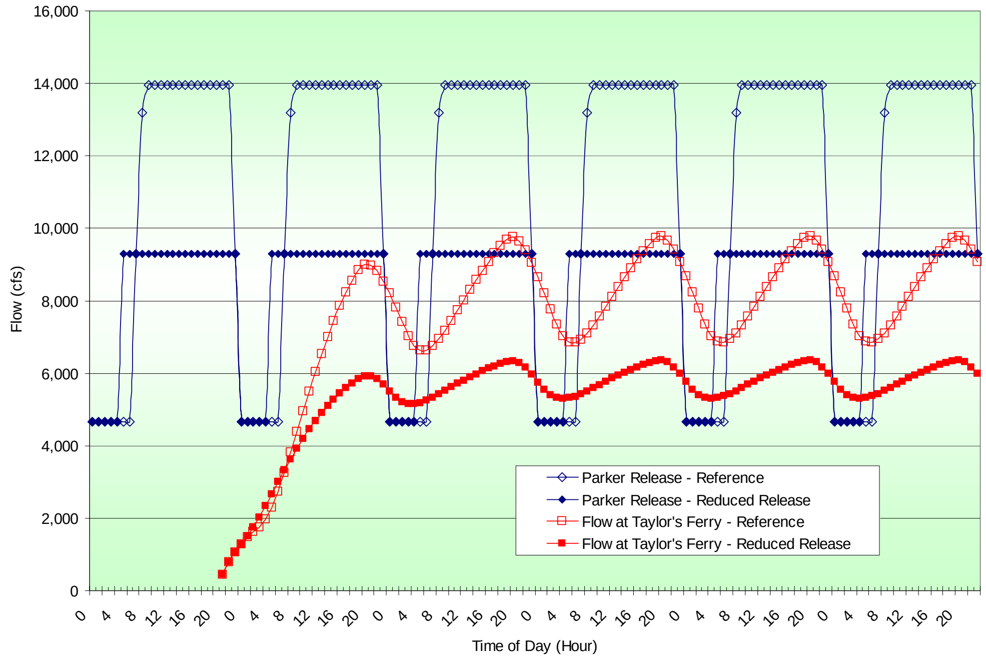


Figure J.D-10
Comparison of River Stage near Taylor Ferry
August—Reference to Reduced Flow (1.574 maf Release Reduction)

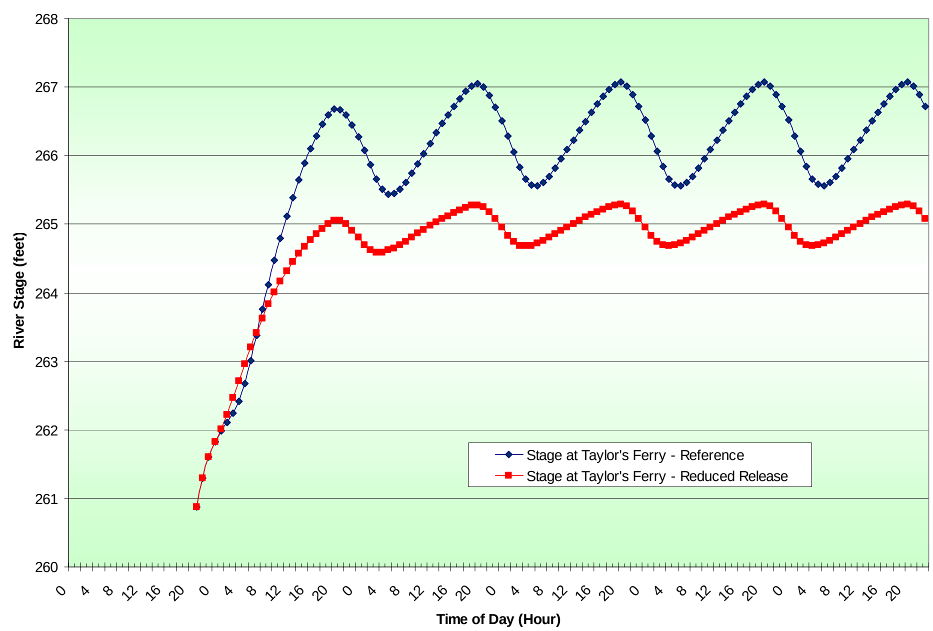


Table J.D-6. Effect of Parker Dam Release Reduction (1.574 maf Reduction) on River Stage at Different River Locations, Monthly Analysis for December, Reference Mean Daily Flow of 4,986 cfs and Reduced Mean Daily Flow of 3,906 cfs

	Reference Flow		Reduced Release		Change	
Location (River Mile)	Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)	Flow (cfs)	Stage (feet)
Mean Daily Release	4,986	NA	3,906	NA	-1,080	NA
171.3	2,424	330.60	2,007	330.31	-417	-0.29
167.6	2,424	323.87	2,007	323.56	-417	-0.31
160.9	2,424	312.30	2,007	311.97	-417	-0.33
149.5	2,424	294.74	2,007	294.32	-417	-0.42
146.9	2,424	292.25	2,007	291.92	-417	-0.33
135.8	2,424	283.50	2,007	283.49	-417	-0.02
119.7	3,530	245.77	2,525	245.04	-1,005	-0.73
116.5	3,530	238.59	2,525	237.59	-1,005	-1.00
114.6	3,530	236.35	2,525	235.39	-1,005	-0.96
109.1	3,530	227.89	2,525	227.00	-1,005	-0.90
103.1	3,530	221.93	2,525	221.21	-1,005	-0.72
96.7	3,530	212.96	2,525	212.10	-1,005	-0.85
86.1	4,476	204.54	3,421	203.70	-1,055	-0.84
80.4	4,476	200.03	3,421	199.41	-1,055	-0.63
72.2	4,476	192.07	3,421	191.43	-1,055	-0.64
70.3	4,476	190.98	3,421	190.32	-1,055	-0.66
66.1	4,476	187.03	3,421	186.46	-1,055	-0.58
56.0	4,857	182.21	3,788	181.66	-1,069	-0.55
53.6	4,857	180.08	3,788	179.86	-1,069	-0.22
50.8	4,857	179.57	3,788	179.54	-1,069	-0.03

Figure J.D-11
Comparison of Parker Dam Release and River Flow near Taylor Ferry
December—Reference to Reduced Flow (1.574 maf Release Reduction)

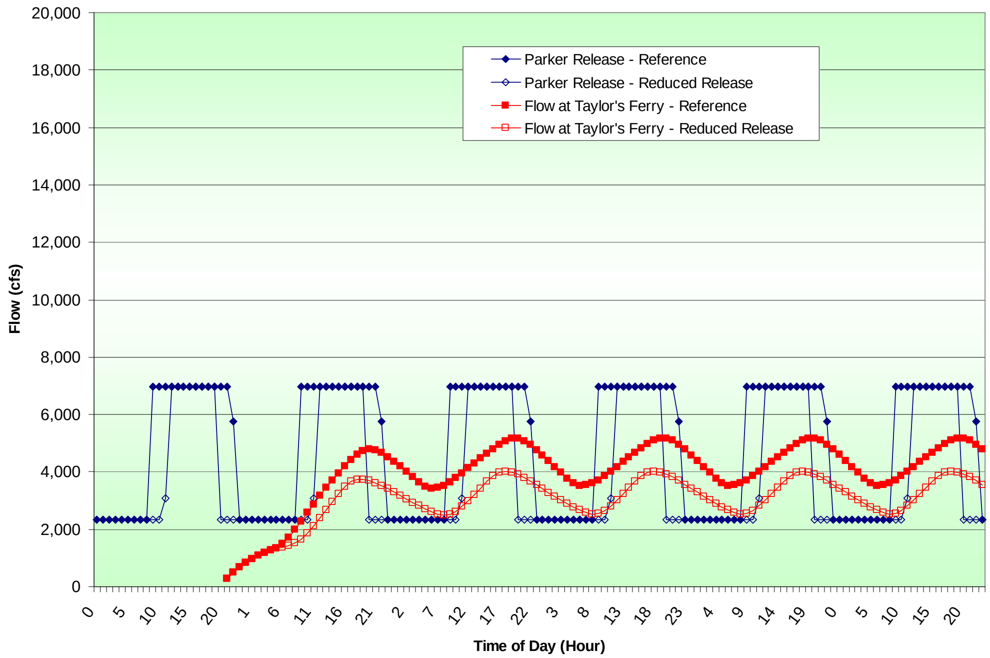
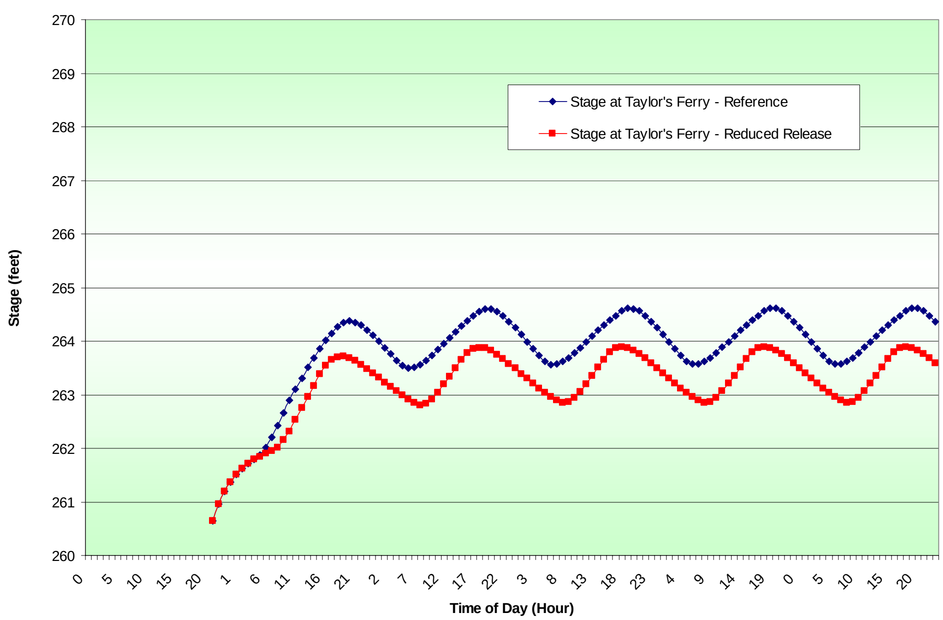


Figure J.D-12
Comparison of River Stage near Taylor Ferry
December—Reference to Reduced Flow (1.574 maf Release Reduction)



Attachment E

Evaluation of Effects Associated with Updated Hydrologic Information

EVALUATION OF EFFECTS ASSOCIATED WITH UPDATED HYDROLOGIC INFORMATION

Table of Contents

EVALUATION OF EFFECTS ASSOCIATED WITH UPDATED HYDROLOGIC INFORMATION

1. INTRODUCTION

Public comments received during the comment period for the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) Draft Environmental Impact Statement/Environmental Impact Report (Draft EIS/EIR, June 18, 2004), Draft Biological Assessment (Draft BA, June 18, 2004) and Draft Habitat Conservation Plan (Draft HCP, June 18, 2004), as published in the Federal Register (69 FR 12202, 3/15/04) noted that the modeling conducted by the U.S. Bureau of Reclamation (Reclamation) for the LCR MSCP relied on hydrologic data that does not reflect the recent dry conditions in the Colorado River Basin. The comments suggested that because of the change in hydrologic conditions, the modeled results underestimate the magnitude of potential impacts to environmental resources within the LCR MSCP planning area.

As a result of these public comments, the participating agencies have prepared this evaluation. The purpose of this evaluation is to determine whether an analysis based on the updated hydrologic information would result in any significant new impacts or changed effects to covered species. This evaluation specifically compares model runs based on the updated hydrologic information, with the model runs based on the previous hydrologic information and considers whether: (1) the impact analysis and the effect determinations provided in the Draft BA/HCP are still accurate in light of the updated hydrologic information; and (2) revisions need to be made in the LCR MSCP documents (EIS/EIR, BA, HCP) pursuant to the regulatory and statutory provisions cited in Section 3 of this document.

2. SUMMARY OF RESULTS

Hydrologic modeling conducted for the Draft BA/HCP utilized hydrologic information based on actual December 31, 2002 elevations of Colorado River reservoirs and the best natural flow data available at that time. The modeling was based on the historic record of natural flow in the river system over the 85-year period from 1906 through 1990.

The analysis conducted as part of this evaluation utilized hydrologic information based on the actual September 30, 2004 elevations of Colorado River reservoirs (including Lake Mead) and updated natural flow data (including years 1991 through 1995). This evaluation concludes that the inclusion of this updated hydrologic information does not identify any significant new impacts or change the conclusions of effect to covered species in the Draft BA/HCP, and no changes are required to the BA, HCP, and EIS/EIR.

The summary findings of this evaluation include the following:

- Use of the December 31, 2002 Colorado River reservoir elevations (including Lake Mead) was appropriate at the time the modeling was prepared for the Draft BA/HCP in early 2003.
- Actual Lake Mead reservoir elevations between January 1, 2003 and the date of this evaluation were within the range projected and analyzed in the Draft BA/HCP.
- Re-computation of flows from 1971–1990 resulted in slightly greater natural inflow into Lake Powell (an increase of approximately 4 percent of the total natural inflow volume over the 20-year period).
- The lower initial reservoir conditions result in an increased probability of shortage conditions under both the Baseline and Action Alternative for the first 25 years.
- Notwithstanding the lower initial reservoir conditions and updated natural flows, the relative differences between Lake Mead elevations under the Baseline and Action Alternative[1] for the Previous and New Modeling were slight, and determined not to be significant.
- The lower initial reservoir conditions result in a slight reduction in the probability of occurrence of flows to Reach 7 under both the Baseline and Action Alternative. However, the relative differences between the Baseline and Action Alternative under the Previous and New Modeling were similar.
- Within the 1.574 million acre-feet (maf) limit of reduced flows in the river modeled and covered by the LCR MSCP, this analysis identified no additional impacts below Hoover Dam in Reaches 3–5.
- The evaluation based on the updated hydrologic information did not identify any significant new environmental impacts or change the conclusions of effect to covered species from the previous analyses.

When dealing with an environmental review process that takes several years, changes in hydrologic conditions are inevitable, and the nature of the hydrologic model utilized by Reclamation is designed to reflect a variety of future possible outcomes. For example, while the initial elevation for Lake Mead has changed between the Previous Modeling (December 31, 2002) and the New Modeling (projected December 31, 2004 conditions), this change was within the variability expected in the Previous Modeling, and depicted in

[1] The use of the term "Baseline" (also referred to as "Baseline scenario" in the LCR MSCP BA and HCP) in this document regarding hydrologic modeling refers to the current operations of the LCR and should not be confused with the definition of "baseline" as used in the ESA regulations or CEQA. Similarly, the use of the phrase "Action Alternative" (also referred to as "Action Alternative scenario" in the LCR MSCP BA and HCP) regarding hydrologic modeling refers to the future operations of the LCR. See Appendix J for further details on the modeling assumptions.

the Draft BA/HCP. As a consequence of the above findings, the participating agencies have determined that no changes in the Draft BA/HCP assessment of effects of covered activities on covered species are required, and a supplemental EIS/EIR is not required.

3. REGULATORY CONTEXT (NEPA/ESA/CEQA)

According to Council on Environmental Quality (CEQ) regulations for implementing the National Environmental Policy Act (NEPA) (40 Code of Federal Regulations [C.F.R.] §1502.9(c)(1)), a Federal agency must prepare a supplement to a Draft EIS if:

- The Federal agency makes substantial changes in the proposed action that are relevant to its environmental effects.
- There are significant new circumstances or information relevant to the environmental concerns that bear on the proposed action or its impacts.

Similarly, the California Environmental Quality Act (CEQA) (Public Resources Code §21000 et seq.) requires the preparation of a subsequent or supplemental EIR if:

- Substantial changes are proposed in the project which will require revisions of the previous EIR.
- Substantial changes occur with respect to the circumstances under which the project is undertaken; or
- New information is available that results in one or more new significant effects or a previously identified effect will be substantially more severe than shown in the previous EIR.

This evaluation is prepared to assist the participating agencies in their determination as to whether a supplement to the Draft EIS/EIR is required at this time based on the updated hydrologic information and effects analysis. In addition, the Federal Endangered Species Act (ESA) requires use of the best available scientific and commercial data in the preparation of a biological assessment (16 U.S.C. §1536(a)(2)). This evaluation will ensure the most accurate analysis by considering the best available and current hydrologic information.

4. CONCERNS RAISED BY PUBLIC COMMENTS

The impact analysis in the Draft BA/HCP was based, in part, on simulations of possible future hydrologic conditions in the Colorado River Basin, including Lake Mead elevations and the frequency of surplus and shortage conditions. These simulations were based upon the historic records of flow in the Colorado River Basin compiled over an 85-year period (1906 through 1990).

Several comment letters on the Draft EIS/EIR and Draft BA/HCP suggested that the environmental impact analysis and effects analysis for covered species "understate the magnitude of potential effects" because they do not include more current hydrologic information from the past few years. Specifically, two issues were raised:

1) In 2003, when work on the Draft EIS/EIR and Draft BA/HCP was undertaken, the initial conditions (starting elevations for each reservoir) used in the modeling were the actual reservoir water surface elevations as of December 31, 2002 (1152 feet above mean sea level [msl] for Lake Mead). Continued drought conditions within the Colorado River Basin have resulted in continued decline of the water surface elevations of the major system reservoirs since the modeling was prepared (projected to be 1123.9 feet msl at Lake Mead as of December 31, 2004).
2) The period of record used as the input hydrology for the modeling was based on the natural flow record that was considered final data at the time of the LCR MSCP analysis in the Draft BA/HCP. The natural flow data, based on the actual recorded data for the period between 1906 through 1990, was used for the analysis. The most recent 13 years of record (1991 through 2003) were not included in the modeling. This recent 13-year period includes both high and low flow years, including one of the driest four-year periods on record (2000 through 2003).

5. RELEVANCE OF THE UPDATED INFORMATION TO ANALYSIS IN THE DRAFT BA/HCP

As stated above, the impact analysis in the Draft BA/HCP was based in part on computer model simulations of future possible hydrologic inflows and current and future Lower Colorado River (LCR) operations. The future LCR system operations for two distinct operational scenarios (Baseline and the Action Alternative) were simulated with the computerized model and the results were compared to determine the relative differences and potential impacts that may result from the Action Alternative (which includes the covered activities in the LCR MSCP) as compared to the Baseline.

The following discussion summarizes the different assumptions used in the two modeled scenarios. Further detail is provided in Appendix J, Volume IV of the LCR MSCP documents. The Baseline condition assumes: 1) transfers of up to 400 thousand acre-feet (kaf) from below to above Parker Dam by 2051 (consistent with the October 10, 2003 Colorado River Water Delivery Agreement); 2) Interim Surplus Guidelines (ISG) remain in place through 2016 and then revert to "70R"[2] (consistent with the January 16, 2001 ISG); and 3) shortages are imposed to maintain Lake Mead at or above elevation 1,083 feet approximately 80 percent of the time in the future, and additional shortages are imposed if needed to protect elevation 1000 feet all of the time.

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[2] The term "70R" refers to a particular surplus strategy that is based on avoiding spills at Lake Mead (see ISG Record of Decision, Section IV (1), January 16, 2001).

The Action Alternative assumes: 1) An additional 1.174 maf of transfers by 2051; 2) extension of the ISG through 2051; and 3) shortages are imposed to maintain Lake Mead at or above elevation 1050 feet approximately 80 percent of the time in the future, and additional shortages are imposed if needed to protect elevation 950 feet all of the time.

5.1 RESERVOIR INITIAL CONDITIONS

Simulated future Lake Mead water surface elevations were used in the analysis of potential impacts to covered species and their habitats in Reach 1, including southwestern willow flycatcher, razorback sucker, humpback chub, sticky buckwheat, and threecorner milkvetch. Lake Mead water surface elevations also affect the frequency of occurrence and magnitude of flood control releases, which in turn may affect flows in Reach 7. The evaluation of potential future conditions was also used to evaluate the potential frequency of shortage and surplus years on the Colorado River. The computerized model and modeling assumptions use certain Lake Mead water surface elevations as triggers to determine the occurrence of shortage or surplus water supply conditions. Surplus and shortage years result in greater or lesser releases from Lake Mead, with potential corresponding changes in flows of the downstream river reaches (Reaches 2–6).

Simulations using the current lower reservoir water surface elevations as the initial conditions[3] show an increase in the probability of lower Lake Mead water surface elevations in future years, as well as an increase in the probability of occurrence of shortage conditions and the associated reductions in Lake Mead releases. These potential changes in future conditions were used to determine if there are any changes in the impacts to covered species and their habitats.

While the model simulations provide the best available information to analyze potential impacts in the future, the model does not provide a prediction as to the elevation of Lake Mead at any point in time. As with most reservoirs, Lake Mead is likely to experience a wide range of elevations over the next 50 years.

5.2 NATURAL FLOWS

Despite the differences in the operating assumptions for the Baseline and the Action Alternative, the future state of the Colorado River system is most sensitive to the future inflows. Predictions of the future inflows, particularly for long-range studies, are highly uncertain. Although the model does not predict future inflows, it can be used to analyze future conditions for a range of possible future inflow conditions.

The possible future inflows used in the Previous Modeling were based on the historic record of natural flow in the river system over the 85-year period from 1906 through 1990. This was the most up-to-date record that was available at the time of

[3] Initial conditions simply refer to the starting elevations of the reservoir in each of the model runs.

the modeling. In May of 2004, Reclamation updated the available record of natural flow. This update included an extensive review of the natural flows from 1971 through 1990. This review resulted in some modifications to the natural flow record. In addition, the record was extended by adding an additional five years, 1991 through 1995 (see Section 6.2).

As a result of the updated natural flow record, projections of future reservoir elevations and releases from Lake Mead may change. These potential changes in future conditions were used to determine if there are any changes in the previously identified impacts to covered species and their habitats as analyzed earlier in the Draft BA/HCP.

While the model simulations provide the best available information to analyze potential impacts in the future, the model does not provide a prediction as to the volume of future releases from Lake Mead in any given year.

6. TREATMENT OF UPDATED HYDROLOGIC INFORMATION

For the purposes of this evaluation, future system conditions were modeled for the Baseline and Action Alternative using the updated reservoir initial conditions and updated natural flow record[4]. All other modeling assumptions (assumptions common to both scenarios as well as assumptions specific to one scenario) were identical to those described in sections J.6.2 and J.6.3 of Appendix J in the June 18, 2004 version of the LCR MSCP Volume IV appendix document. With the exception of the updated reservoir initial conditions (projected for December 31, 2004) the model period in this analysis is the same as in the Draft BA/HCP (i.e., through 2051).

The new model output was evaluated and used to ascertain whether the revisions to the model and modeling assumptions provide different results from the previous impact analysis and effect determinations in the Draft BA/HCP.

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[4] Reclamation utilized recorded hydrological data compiled over the past century in the Draft BA/HCP. Public comments received on these documents suggested that Reclamation utilize estimates of hydrologic conditions that predate the flow record of the past century. Comments also suggested that Reclamation predict the effect of climate change on flows in the Colorado River. Reclamation believes that use of the actual data recorded over the past century provides the best basis for ongoing Colorado River management activities and analyses associated with those activities. Accordingly, Reclamation has not modified this approach in this evaluation or in the Final BA/HCP. If Reclamation were to use a different modeling approach in the analysis of the LCR MSCP, it would conflict with all of the other Colorado River management actions and analyses that Reclamation has taken and is currently taking. It is important to note that by periodically including additional hydrologic data, Reclamation will account for changes related to runoff patterns and or human demand. While these particular comments focused on potential affects of climate change on inflows into the Colorado River, this is just one of many variables that may affect runoff and demand within the Colorado River basin. Attempting to predict global changes in climate, shifts in demographic patterns, and other factors affecting Colorado River hydrology are far more speculative than Reclamation's reliance on actual annual hydrologic data.

For the purposes of discussion and comparison of the modeling results, the modeling conducted as part of the previous impact analysis is hereinafter referred to as the "Previous Modeling." The new model runs that were conducted specifically for this evaluation and that reflect the projected December 31, 2004 reservoir initial conditions and the updated natural flow record period between 1906–1995 is hereinafter referred to as the "New Modeling."

The revisions to the model are detailed below.

6.1 RESERVOIR INITIAL CONDITIONS

A comparison of the previous and updated initial reservoir conditions is presented in Table 1. Use of the December 31, 2002 Lake Mead elevation was appropriate at the time the modeling for the Draft BA/HCP was prepared during 2003 (Previous Modeling), as it represented the most recent actual end of the year data.

The updated initial reservoir starting conditions for this evaluation (New Modeling) are based on the actual elevations of Colorado River reservoirs as of September 30, 2004. Reclamation's mid-term operations model (the 24-Month Study) was used to project these elevations to December 31, 2004, using projected operations for the remainder of the 2004 calendar year that include projected unregulated inflows into the Upper Basin, as well as projected inflows and demand schedules for the Lower Basin.

As depicted in Table 1, the new initial reservoir conditions on Lake Mead are approximately 28 feet lower than the previous initial reservoir conditions.

Table 1
Comparison of Previous and New Modeled Initial Reservoir Conditions

	Previous Initial Reservoir Conditions (midnight, December 31, 2002)		New Initial Reservoir Conditions (midnight, December 31, 2004)	
Reservoir	Water Surface Elevation (feet msl)	Storage (kaf)	Water Surface Elevation (feet msl)	Storage (kaf)
Fontenelle	6487.79	213	6485.47	199
Flaming Gorge	6009.71	2,632	6012.06	2,709
Taylor Park	9288.42	41	9307.52	66
Blue Mesa	7444.59	283	7480.47	509
Morrow Point	7150.72	110	7153.73	112
Crystal	6742.41	14	6746.05	15
Navajo	6010.55	827	6017.93	893
Powell	3620.10	13,774	3565.19	8,724
Mead	**1152.13**	**16,718**	**1123.93**	**13,744**
Mohave	642.27	1,679	638.71	1,583
Havasu	446.21	547	445.80	539
Total system storage	**Not Applicable**	**36,838**	**Not Applicable**	**29,093**

Note: msl = above mean sea level; kaf = thousand acre-feet

6.2 NATURAL FLOWS

The term "natural flow" is defined as the observed flow, corrected for upstream consumptive uses and the effects of upstream reservoirs. In May 2004, Reclamation updated the available historic record of natural flow for all 29 inflow points represented in the model. This update included an extensive review of the 1971–1990 Upper Basin consumptive uses and reservoir regulation.[5] Some errors and omissions were corrected and the natural flows were re-computed for that period. In addition, the consumptive uses and reservoir regulation records were completed and reviewed for the 1991–1995 period and natural flows were computed through 1995. In order to include the most recent and accurate information in this evaluation, this updated natural flow information was included in the New Modeling.

Figure 1 compares the previous and updated records of natural inflow to Lake Powell for 1971–1995. The re-computation over the period 1971–1990 resulted in somewhat higher natural flows than were previously published (an increase of approximately 10.9 maf or about 4 percent of the total volume for that 20-year period).

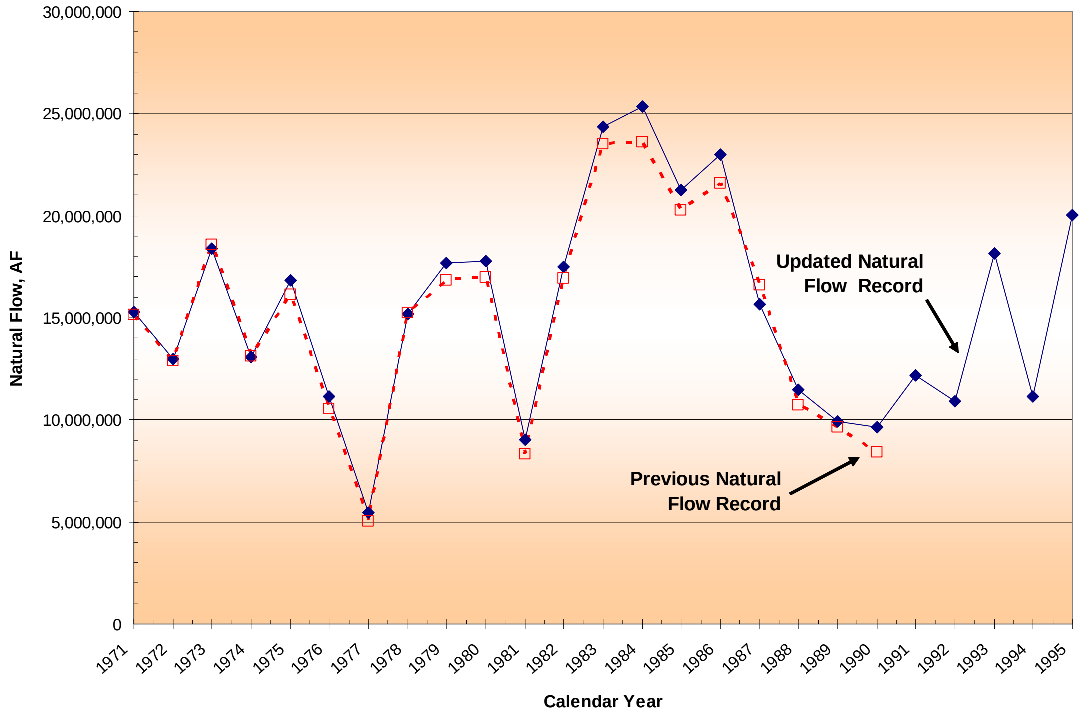
These data were used as input to the Index Sequential Method (ISM) to obtain a range of possible future inflows (see Section J.6.6 of Appendix J). The ISM in the Previous Modeling resulted in 85 separate simulations (referred to as "traces") for each operating scenario that was analyzed. The inclusion of the updated natural flow record period (1906–1995) now results in 90 separate simulations or traces for each operating scenario.

The most recent eight years of record (1996–2003), which includes one of the driest four-year periods on record, were not included in the modeling for this evaluation because the natural flow analysis has not been completed for these years. The records of consumptive use in the Upper Basin for 1996–2000 are currently only available in provisional form and the resulting natural flows have not been thoroughly peer reviewed. Because of this, Reclamation determined that the provisional data should not be used for evaluation of potential environmental impacts. Furthermore, consumptive uses in the Upper Basin for 2001–2003 are currently not available. It should be noted that even if the most recent eight years of record were included, no substantial changes to the future conditions would be expected, since the eight years includes years of above-average flow, as well as below-average flow. The historic record used by Reclamation in its hydrologic modeling includes periods of low flow on the Colorado River that are similar to the

[5] This extensive review was conducted by Reclamation's Upper and Lower Colorado Region modeling staff, the Work Group of the Colorado River Salinity Control Forum, and water resources staff from each of the seven Colorado River Basin states, as well as by peer review of articles submitted for publication to appropriate refereed technical journals.

current drought.[6] Moreover, if additional low-flow years were added to the data used for the hydrologic modeling, the lowest expected elevation of Lake Mead would not change, because Reclamation's modeling assumptions for management of Lake Mead is designed to prevent Lake Mead from declining below 950 feet msl.[7] The records being provided and used comprise the most current and best available information at the time of this evaluation.[8]

Figure 1
Previous and Updated Natural Flow Record



6.3 DATA INTERPRETATION PROCEDURES

As previously stated, the model generates 85 traces for the Previous Modeling or 90 traces for the New Modeling using the ISM. For a given point in time (e.g., year

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6 For example, the following periods of low flow are included in the historic record: 1931-1935 (5 year average: 11.4 maf); 1953-1956 (4 year average: 10.2 maf); 1959-1964 (6 year average: 11.4 maf); 1988-1992 (5 year average: 10.9 maf). Current estimates of the most recent five years of data, 2000-2004 show that the 5 year average is 9.9 maf.

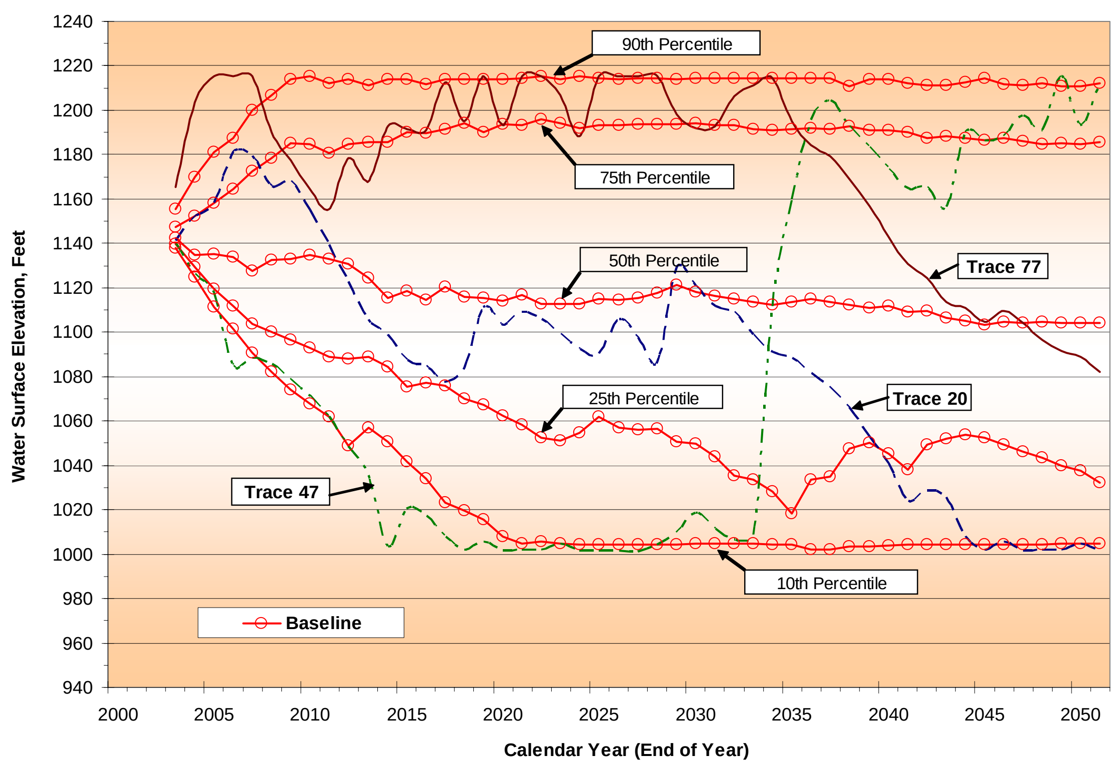
7 For a full discussion of the modeling assumptions regarding Lake Mead elevation management strategies, see Appendix J, Section 6.1.

8 Reclamation continuously reviews its processes for determining the consumptive uses throughout the Upper Basin (in cooperation with the Upper Basin States) and is committed to identifying improvements that when implemented, should allow for the collection, analysis, and publication of Upper Basin consumptive uses and natural flows on a more frequent basis.

2010) and for each variable (e.g., Lake Mead elevation), there are 85 or 90 possible outcomes for that variable. Various statistical and numerical techniques can be applied to those outcomes and used for the subsequent hydrologic and resource impact analyses.

For example, Figure 2 shows three of the 85 traces for Lake Mead elevation under the Baseline for the Previous Modeling (traces 20, 47, and 77). Recall that each trace represents the projection for a particular future inflow scenario and a comparison of the traces illustrates the variability in future Lake Mead elevations. However, none of the traces is a prediction of future Lake Mead elevations. The highs and lows shown in the three traces would likely be temporary conditions and the reservoir level would be expected to fluctuate within the ranges shown. Neither the timing of water level variations between the highs and lows, nor the length of time the water level would remain high or low can be predicted.

Figure 2
Lake Mead End-of-December Water Elevations under Baseline (Previous Modeling) — 90th, 75th, 50th, 25th, and 10th Percentile Values and Representative Traces



A common analysis technique simply ranks the possible outcomes at each time (in this example, the end-of-December Lake Mead elevations for each year) and uses the ranked outcomes to compute other statistics of interest. For example, if end-of-December Lake Mead elevations are ranked for each year, the median outcome for a given year is the elevation for which half of the values are below and half are above.

This outcome is therefore referred to as the "median value" or the "50^{th} percentile value." Similarly, the elevation for which 25 percent of the values are less than or equal to in a given year, is denoted as the 25^{th} percentile value. Several presentations of the ranked data are then possible. A graph (or table) may be produced that compares the 75^{th} percentile, 50^{th} percentile, and 25^{th} percentile outcomes from both the Previous and New Modeling. In addition to the three traces noted above, the 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} percentile lines derived from all 85 traces are also shown on Figure 2.

Again, it must be noted that a specific percentile line is not the result of any one future hydrologic inflow scenario, nor is it a prediction of future reservoir elevations. A simple interpretation of the 25^{th} percentile shown in Figure 2 is that in a given year (e.g., 2010), Lake Mead elevations are likely to be above the 25^{th} percentile value (approximately 1095 feet) with a 75 percent probability. This interpretation is based on the assumption that the flow sequences seen in the historical record will be repeated in the future, as assumed by the ISM.

7. ANALYSIS OF UPDATED HYDROLOGIC INFORMATION ON BIOLOGICAL RESOURCES

The potential effects of the updated information on future LCR reservoir and river operations conditions were evaluated. This evaluation is consistent with those previously conducted and is intended to provide an indication as to whether the updated hydrologic information has an effect on the previous impact analysis in the Draft BA/HCP. In particular, this evaluation was conducted to determine:

- effect on Lake Mead water surface elevations,
- effect on the river corridor (Reaches 3–5), and
- effect on flows to Reach 7.

For each of these three topic areas, this section presents: 1) a summary of the results from the previous hydrologic modeling, 2) a summary of the results from the new hydrologic modeling, 3) a comparison of the new to previous hydrologic modeling results, and 4) an analysis of the effect of the new hydrologic modeling on biological resources.

The biological resources analysis in this section describes potential effects to habitats utilized by those covered species that are potentially affected by the updated hydrologic information. The habitat types (i.e., riparian, marsh, etc.,) considered are consistent with the analysis in the Draft BA/HCP.

In evaluating the effect of the updated hydrologic information, this evaluation focuses on the difference between the Baseline and Action Alternative for the Previous Modeling as compared to the New Modeling. However, the evaluation also considers the context in which these differences occur. For example, consider a comparison of the differences between the median Lake Mead water surface elevations under the Action Alternative and Baseline for a particular year. Assume that under the Previous Modeling, the analysis indicated that the median water surface elevation under the Action Alternative was 10 feet lower than under the Baseline. Further assume that the new analysis indicated that the water surface elevation under the Action Alternative would be 15 feet lower than under the Baseline for that particular year. This evaluation considers not only the incremental 5-foot difference in the median Lake Mead elevation, but also whether that difference may have additional impacts because it occurs at a lower elevation in the reservoir.

7.1 EFFECT ON LAKE MEAD WATER SURFACE ELEVATIONS

As discussed in Appendix J, the covered activities would have no effect on the operation of Lake Mohave, Lake Havasu, or Imperial Dam. Therefore, the only reservoir system conditions that were previously analyzed are the Lake Mead water levels. The previous analysis of potential effects of the LCR MSCP on Lake Mead water levels was summarized in Appendix J, Section J.6.

The previous analysis provided a comparison of the results of the future Lake Mead water level simulations for the Baseline and the Action Alternative. A similar analysis was conducted based on the New Modeling.

For comparison purposes, lake levels are presented on an annual basis using water levels at the end of December for each year.

7.1.1 Results from Previous Hydrologic Modeling

Figure 3 presents a comparison of the 75th, 50th, and 25th percentile lines obtained for the Baseline to those obtained for the Action Alternative under the Previous Modeling. These lines represent the respective 75th, 50th, and 25th percentile values of the 85 traces (simulations) for each respective year.

As illustrated in Figure 3, median Lake Mead elevations under the Baseline and Action Alternative decline throughout the period of analysis. This is due to the effect of increasing Upper Basin depletions, which decreases the probability of equalization releases from Lake Powell over time. Figure 3 also illustrates that up to 2020, median elevations are higher under the Action Alternative when compared to the Baseline (an average of approximately 5.3 feet higher over the period 2003–2020). As noted in Appendix L, Volume IV of the LCR MSCP documents, this result can be attributed to the implementation of water transfers under the Action Alternative that reduce the call for surplus water from Lake Mead, resulting in somewhat higher Lake Mead levels. After 2020, at the median level, the positive effect due to the transfers is outweighed by the effects of extending the ISG to 2051 and lowering the shortage strategy (an average difference of approximately –6.7 feet over the period 2021–2050).

7.1.2 Results from New Hydrologic Modeling

Figure 4 presents a comparison of the 75th, 50th, and 25th percentile lines obtained for the Baseline to those obtained for the Action Alternative under the New Modeling. These lines represent the respective 75th, 50th,and 25th percentile values of the 90 traces (simulations) for each respective year.

As illustrated in Figure 4, the 75th, 50th, and 25th percentile lines for both the Baseline and Action Alternative begin at a lower elevation than that shown in

Figure 3
Previous Modeling
Lake Mead End-of-December Water Elevations
Comparison of Baseline to Action Alternative
for 75th, 50th, and 25th Percentile Values

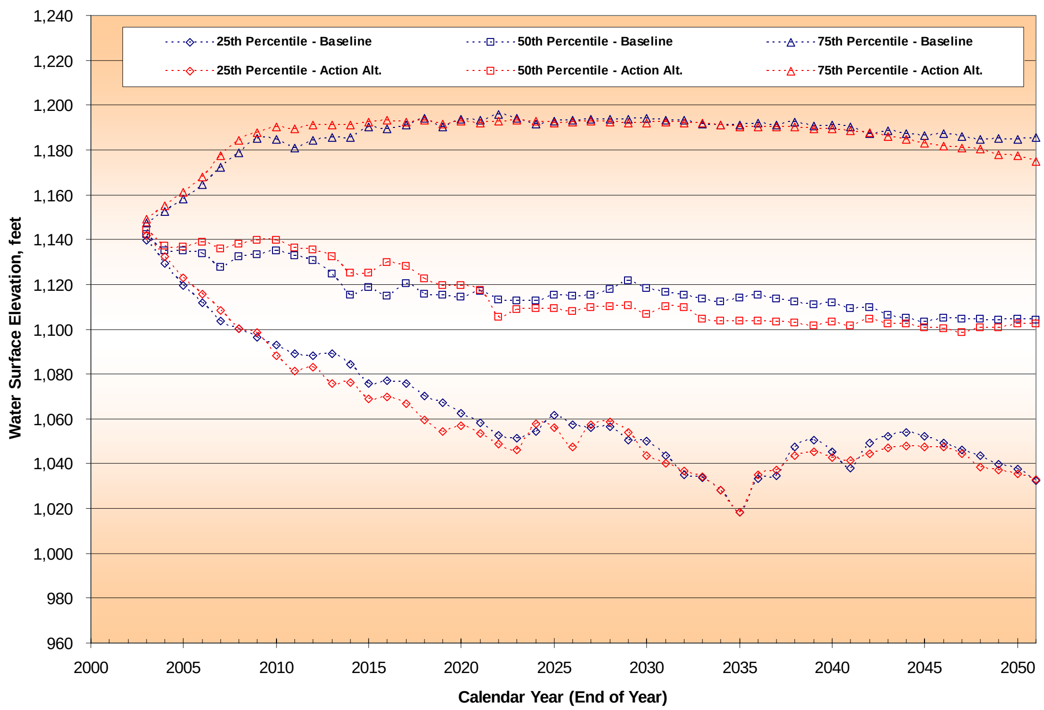
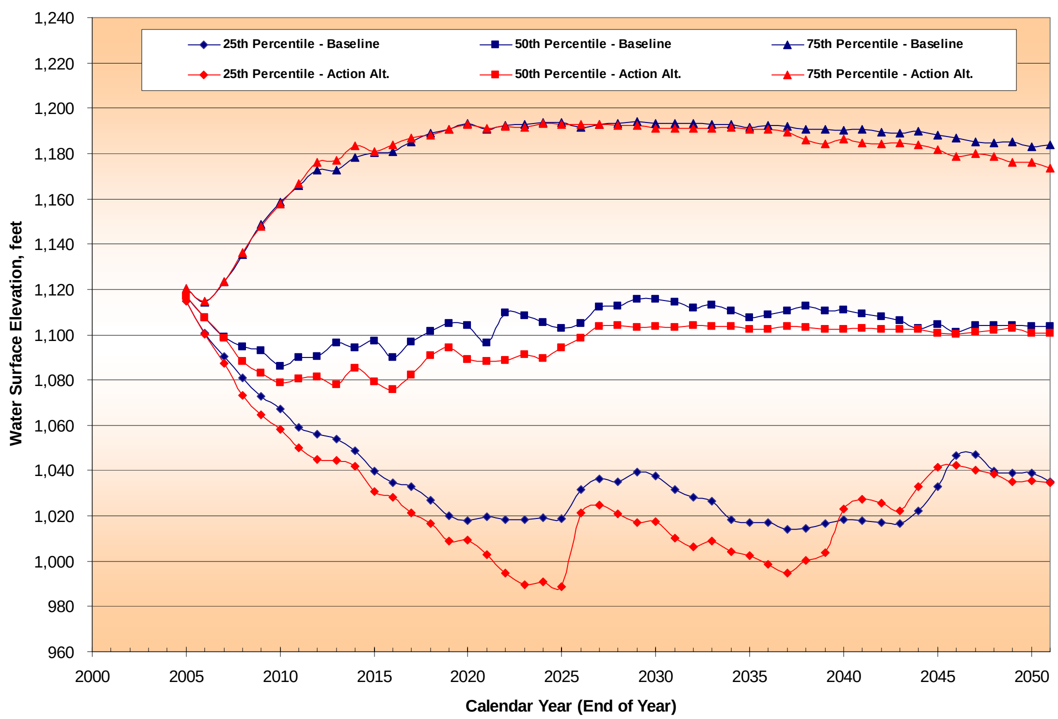


Figure 3 (Previous Modeling), which is due to the lower Lake Mead initial reservoir conditions. Recall that for the Previous Modeling, the initial reservoir water surface elevation was 1152.13 feet above mean sea level (msl) (December 31, 2002) and for the New Modeling, the initial water surface elevation was 1123.93 feet msl (December 31, 2004), a difference of about 28 feet.

Figure 4 shows that the median Lake Mead elevations under the modeled Baseline and Action Alternative decline through year 2010, then increase through year 2027, and remain generally level thereafter. The decline in median Lake Mead elevations resulting from increasing Upper Basin depletions (shown in Figure 3 for the 50th percentile) does not occur under the New Modeling. This is because the probability of equalization in the near term is less due to the lower starting elevations at both Lake Powell and Lake Mead. Therefore, the effect of increasing Upper Basin depletions is negligible in the near term. The median Lake Mead elevations under the Action Alternative are generally lower than under the Baseline until about 2044, whereas thereafter, they are approximately the same. Through year 2010, the median Lake Mead elevations under the Action Alternative are, on average, approximately 4 feet lower than those under the Baseline. Between years 2010 and 2040, the median Lake Mead elevations under the Action Alternative are an average of approximately 10 feet lower than those under the Baseline.

Figure 4
New Modeling
Lake Mead End-of-December Water Elevations
Comparison of Baseline to Action Alternative
for 75th, 50th, and 25th Percentile Values



7.1.3 Comparison of Previous and New Hydrologic Modeling

This section provides a comparison of New and Previous Modeling results.

Figure 5 provides a graphical comparison of the 75th, 50th, and 25th percentile lines obtained for the Baseline and Action Alternative under the New and Previous Modeling. A similar comparison in tabular format is provided in Table 2.

As previously noted, the median Lake Mead elevations for both the Baseline and Action Alternative under the New Modeling begin at a lower elevation than those under the Previous Modeling due to the lower initial reservoir conditions[9].

In Table 3, the relative differences due to the updated information are compared. Columns 2–4 and Columns 5–7 of Table 3 compare the differences between the 75th, 50th, and 25th percentile values obtained under the Baseline and Action Alternative under the Previous and New Modeling, respectively. In Columns 8–10 of this same table, the relative differences between the New and Previous Modeling results are compared.

As shown in Table 3, differences between the Baseline and Action Alternative median Lake Mead water surface elevations under the New Modeling are somewhat greater than those under the Previous Modeling. These differences are greater between years 2006 and 2024. During this period, the maximum difference is 29 feet and the average is approximately 11 feet. Contributing to these differences is the fact that under the Previous Modeling, the Action Alternative provided higher median Lake Mead water surface elevations than under the Baseline (see Figure 3 for the 50th percentile). As noted above and described in Appendix L, this result is due to the reduced need for surplus water attributed to the implementation of water transfers. Under the New Modeling, this effect is negated as a result of the lower initial reservoir conditions (i.e., the Lower Basin is not in surplus as often in the years up to 2024).

[9] Notwithstanding the lower initial conditions reflected in the New Modeling, actual Lake Mead elevations between January 1, 2003 and the date of this analysis were within the range projected in the Draft BA/HCP based on Previous Modeling.

Figure 5
Comparison of New to Previous Modeling Results
Lake Mead End-of-December Water Elevations
for 75th, 50th, and 25th Percentile Values

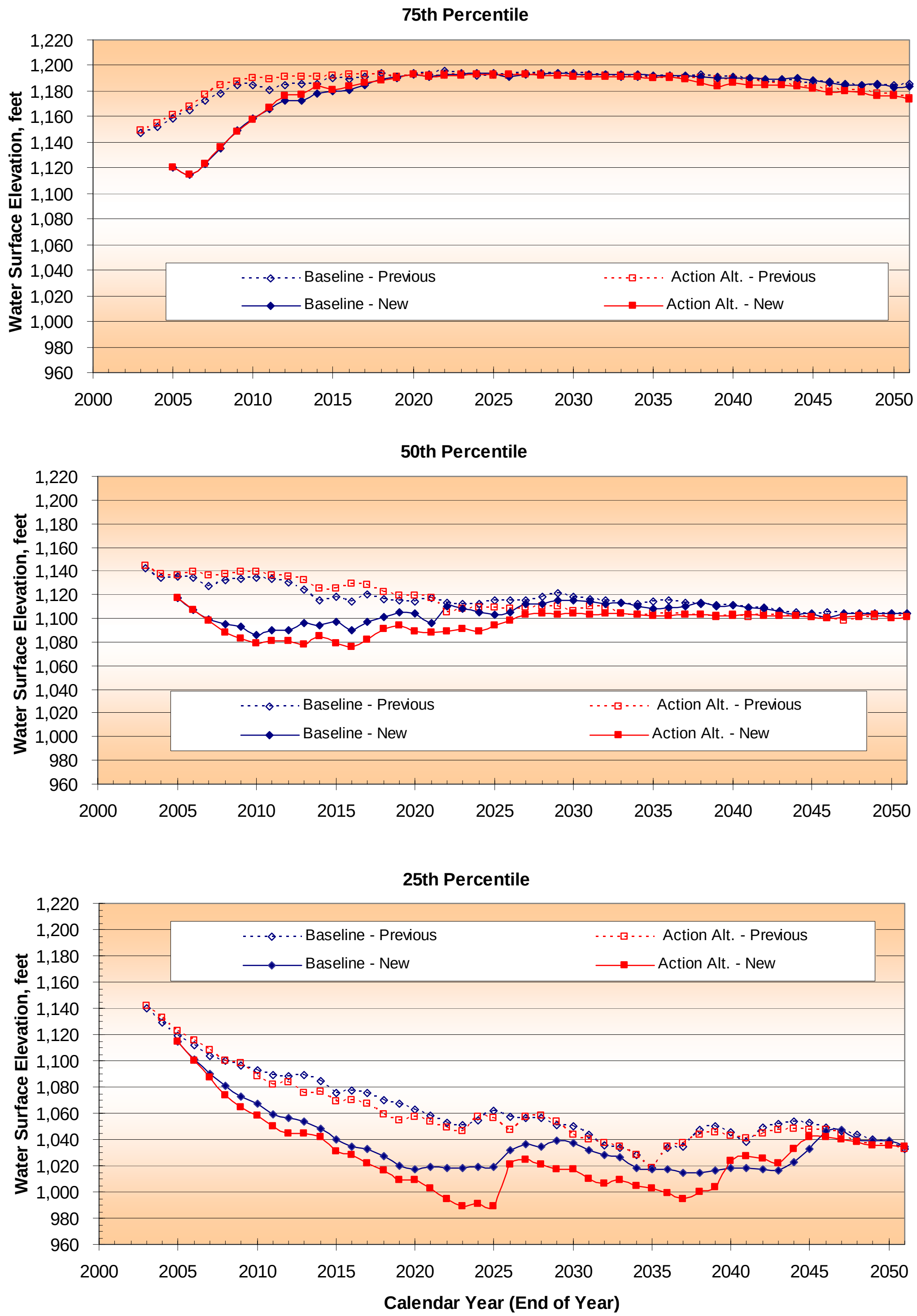


Table 2
Comparison of Lake Mead End-of-December Water Elevations (feet msl)
Under Previous and New Modeling for 75th, 50th, and 25th Percentiles Values

	Previous Modeling						New Modeling					
	Baseline			Action Alternative			Baseline			Action Alternative		
[1]	*[2]*	*[3]*	*[4]*	*[5]*	*[6]*	*[7]*	*[8]*	*[9]*	*[10]*	*[11]*	*[12]*	*[13]*
Year	25th Percentile	50th Percentile	75th Percentile	25th Percentile	50th Percentile	75th Percentile	25th Percentile	50th Percentile	75th Percentile	25th Percentile	50th Percentile	75th Percentile
2003	1,140	1,142	1,147	1,142	1,144	1,149						
2004	1,129	1,135	1,152	1,132	1,137	1,155						
2005	1,119	1,135	1,158	1,123	1,137	1,161	1,115	1,117	1,121	1,115	1,117	1,121
2006	1,112	1,134	1,165	1,116	1,139	1,168	1,101	1,108	1,114	1,100	1,108	1,115
2007	1,104	1,128	1,172	1,108	1,136	1,177	1,090	1,099	1,123	1,087	1,098	1,123
2008	1,100	1,132	1,178	1,100	1,138	1,184	1,081	1,095	1,135	1,073	1,088	1,136
2009	1,096	1,133	1,185	1,099	1,140	1,188	1,073	1,093	1,149	1,064	1,083	1,148
2010	1,093	1,135	1,185	1,088	1,139	1,190	1,067	1,086	1,159	1,058	1,079	1,157
2011	1,089	1,133	1,181	1,081	1,136	1,189	1,059	1,090	1,166	1,050	1,081	1,167
2012	1,088	1,131	1,184	1,083	1,135	1,191	1,056	1,090	1,173	1,045	1,081	1,176
2013	1,089	1,125	1,186	1,076	1,132	1,191	1,054	1,096	1,173	1,044	1,078	1,177
2014	1,084	1,115	1,186	1,076	1,125	1,191	1,049	1,094	1,178	1,042	1,085	1,183
2015	1,076	1,119	1,190	1,069	1,125	1,192	1,040	1,097	1,180	1,031	1,079	1,181
2016	1,077	1,115	1,190	1,070	1,130	1,193	1,035	1,090	1,181	1,028	1,076	1,184
2017	1,076	1,120	1,191	1,067	1,128	1,193	1,033	1,097	1,185	1,021	1,082	1,187
2018	1,070	1,116	1,194	1,059	1,123	1,193	1,027	1,102	1,189	1,017	1,091	1,188
2019	1,067	1,115	1,190	1,054	1,120	1,191	1,020	1,105	1,191	1,009	1,094	1,191
2020	1,062	1,114	1,193	1,057	1,119	1,193	1,018	1,104	1,193	1,009	1,089	1,193
2021	1,058	1,117	1,193	1,053	1,117	1,192	1,019	1,096	1,191	1,003	1,088	1,191
2022	1,053	1,113	1,196	1,049	1,105	1,193	1,018	1,110	1,193	995	1,089	1,192
2023	1,051	1,113	1,194	1,046	1,109	1,193	1,018	1,108	1,193	989	1,091	1,192
2024	1,054	1,113	1,192	1,058	1,109	1,193	1,019	1,105	1,194	991	1,089	1,193
2025	1,062	1,115	1,193	1,056	1,109	1,192	1,019	1,103	1,194	989	1,094	1,193
2026	1,057	1,115	1,193	1,048	1,108	1,192	1,032	1,105	1,191	1,021	1,098	1,193
2027	1,056	1,115	1,194	1,057	1,110	1,193	1,036	1,112	1,193	1,025	1,104	1,193
2028	1,057	1,118	1,194	1,058	1,110	1,193	1,035	1,112	1,193	1,021	1,104	1,192
2029	1,051	1,121	1,194	1,054	1,110	1,192	1,039	1,116	1,194	1,017	1,103	1,192
2030	1,050	1,118	1,194	1,043	1,107	1,192	1,038	1,116	1,193	1,017	1,104	1,191
2031	1,044	1,116	1,193	1,040	1,110	1,192	1,032	1,114	1,193	1,010	1,103	1,191
2032	1,035	1,115	1,193	1,037	1,110	1,192	1,028	1,112	1,193	1,006	1,104	1,191
2033	1,034	1,114	1,191	1,034	1,104	1,192	1,027	1,113	1,193	1,009	1,104	1,191
2034	1,028	1,112	1,191	1,028	1,104	1,191	1,018	1,110	1,193	1,004	1,103	1,192
2035	1,018	1,114	1,191	1,018	1,104	1,190	1,017	1,108	1,192	1,002	1,102	1,191
2036	1,033	1,115	1,192	1,035	1,104	1,190	1,017	1,109	1,192	999	1,102	1,191
2037	1,035	1,113	1,191	1,037	1,103	1,190	1,014	1,110	1,192	995	1,104	1,189
2038	1,047	1,112	1,193	1,043	1,103	1,190	1,014	1,113	1,191	1,000	1,103	1,186
2039	1,050	1,111	1,191	1,045	1,101	1,189	1,017	1,111	1,191	1,004	1,102	1,184
2040	1,045	1,112	1,191	1,043	1,103	1,190	1,018	1,111	1,190	1,023	1,102	1,186
2041	1,038	1,109	1,190	1,041	1,101	1,188	1,018	1,109	1,190	1,027	1,103	1,185
2042	1,049	1,110	1,187	1,045	1,104	1,188	1,017	1,108	1,189	1,026	1,103	1,184
2043	1,052	1,106	1,188	1,047	1,102	1,186	1,017	1,106	1,189	1,022	1,102	1,185
2044	1,054	1,105	1,187	1,048	1,102	1,185	1,022	1,103	1,190	1,033	1,102	1,184
2045	1,052	1,103	1,187	1,048	1,101	1,183	1,033	1,104	1,188	1,042	1,101	1,182
2046	1,049	1,105	1,187	1,047	1,100	1,182	1,047	1,101	1,187	1,042	1,100	1,179
2047	1,046	1,104	1,186	1,045	1,098	1,181	1,047	1,104	1,185	1,040	1,101	1,180
2048	1,044	1,104	1,185	1,038	1,101	1,180	1,040	1,104	1,185	1,038	1,102	1,179
2049	1,040	1,104	1,185	1,037	1,101	1,178	1,039	1,104	1,185	1,035	1,103	1,176
2050	1,037	1,104	1,185	1,036	1,102	1,177	1,039	1,104	1,183	1,036	1,101	1,176
2051	1,032	1,104	1,186	1,033	1,102	1,175	1,035	1,104	1,184	1,035	1,101	1,174

Note: msl = above mean sea level

Table 3
Comparison of Differences Between Previous and New Modeling Results
Lake Mead End-of-December Water Elevations[10] (feet msl)
75th, 50th, and 25th Percentiles Values

	Previous Modeling Differences[11] Between Baseline and Action Alternative			New Modeling Differences[5] Between Baseline and Action Alternative			Differences[5] Between New to Previous Modeling		
[1]	*[2]*	*[3]*	*[4]*	*[5]*	*[6]*	*[7]*	*[8]*	*[9]*	*[10]*
Year	25th Percentile	50th Percentile	75th Percentile	25th Percentile	50th Percentile	75th Percentile	25th Percentile	50th Percentile	75th Percentile
2003	2	2	2						
2004	3	2	3						
2005	4	2	3	(0)	0	(0)	(4)	(2)	(3)
2006	4	5	3	(0)	(0)	1	(4)	(5)	(3)
2007	5	8	5	(3)	(1)	(0)	(8)	(9)	(5)
2008	0	6	6	(8)	(7)	1	(8)	(12)	(5)
2009	2	7	3	(8)	(10)	(1)	(11)	(16)	(3)
2010	(5)	5	5	(9)	(7)	(1)	(4)	(12)	(6)
2011	(7)	3	9	(9)	(9)	1	(1)	(13)	(8)
2012	(5)	5	7	(11)	(9)	3	(7)	(13)	(3)
2013	(13)	8	5	(10)	(18)	4	3	(26)	(1)
2014	(8)	10	5	(7)	(9)	5	2	(19)	(0)
2015	(7)	6	2	(9)	(18)	1	(2)	(24)	(1)
2016	(8)	15	4	(7)	(14)	3	1	(29)	(1)
2017	(9)	8	1	(12)	(15)	2	(3)	(22)	1
2018	(11)	7	(1)	(10)	(11)	(1)	1	(18)	(0)
2019	(13)	4	1	(11)	(11)	(0)	1	(15)	(1)
2020	(5)	5	(1)	(8)	(15)	(1)	(3)	(20)	0
2021	(5)	0	(1)	(17)	(8)	0	(12)	(9)	2
2022	(4)	(8)	(3)	(23)	(21)	(1)	(20)	(14)	2
2023	(5)	(4)	(1)	(29)	(17)	(1)	(24)	(13)	(0)
2024	3	(4)	1	(28)	(16)	(1)	(32)	(12)	(2)
2025	(6)	(6)	(1)	(30)	(9)	(1)	(25)	(3)	(0)
2026	(10)	(7)	(1)	(11)	(7)	1	(1)	(0)	2
2027	1	(6)	(1)	(12)	(9)	(0)	(13)	(3)	1
2028	2	(8)	(1)	(14)	(8)	(1)	(16)	(1)	0
2029	3	(11)	(2)	(22)	(12)	(2)	(26)	(1)	(0)
2030	(6)	(12)	(2)	(20)	(12)	(2)	(14)	(0)	0
2031	(4)	(6)	(1)	(21)	(11)	(2)	(18)	(5)	(1)
2032	2	(6)	(1)	(22)	(8)	(2)	(23)	(2)	(1)
2033	1	(9)	0	(17)	(9)	(2)	(18)	(0)	(2)
2034	0	(9)	(0)	(14)	(7)	(1)	(14)	2	(1)
2035	(0)	(10)	(1)	(15)	(5)	(1)	(15)	5	(0)
2036	2	(11)	(2)	(18)	(6)	(1)	(20)	5	0
2037	2	(10)	(1)	(19)	(7)	(3)	(22)	3	(2)
2038	(4)	(10)	(2)	(14)	(10)	(5)	(10)	0	(3)
2039	(5)	(9)	(2)	(13)	(8)	(6)	(8)	1	(5)
2040	(2)	(9)	(2)	5	(9)	(4)	7	(0)	(2)
2041	3	(8)	(2)	9	(7)	(6)	6	1	(4)
2042	(5)	(5)	0	8	(5)	(5)	13	(0)	(5)
2043	(5)	(4)	(3)	6	(4)	(4)	11	0	(2)
2044	(6)	(3)	(3)	10	(1)	(6)	16	2	(3)
2045	(5)	(2)	(4)	9	(4)	(6)	13	(1)	(3)
2046	(2)	(5)	(6)	(4)	(1)	(8)	(3)	4	(2)
2047	(2)	(6)	(5)	(7)	(3)	(5)	(5)	3	(0)
2048	(5)	(4)	(4)	(2)	(2)	(6)	4	1	(2)

[10] Although the modeling results are at a high precision, differences presented in this table reflect rounding to the nearest integer value.
[11] The differences between the Baseline and Action Alternative were calculated by subtracting Baseline Value from the Action Alternative Value and the differences between the New and Previous Modeling conditions were calculated by subtracting the Previous Modeling Value from the New Modeling Value.

2049	(2)	(3)	(7)	(4)	(1)	(9)	(1)	2	(2)
2050	(2)	(2)	(7)	(3)	(3)	(7)	(1)	(1)	0
2051	1	(2)	(11)	(0)	(3)	(10)	(1)	(2)	1

Note: msl = above mean sea level

7.1.4 Analysis of Effect on Biological Resources

7.1.4.1 Riparian Vegetation

The operation of Lake Mead is analogous to a natural ecosystem with cycles of riparian vegetation growth and loss, particularly in the delta areas of the Virgin River, Muddy River, and Colorado River as it exits the Grand Canyon. However, these cycles that include scouring of vegetation may occur with different frequency than on a natural stream system.[12]

The Lake Mead delta areas have a great potential for use by a large and diverse number of avian species, but are limited in their importance due to their ephemeral nature. This ephemeral riparian vegetation that establishes in these delta areas can provide habitat for many bird species, including covered species, such as the southwestern willow flycatcher, yellow warbler, summer tanager, and Bell's vireo, and is used for breeding, migration stopover, and as wintering habitat. As riparian vegetation develops as habitat for these species, their abundance and productivity rises substantially. Conversely, as vegetation dries out when reservoir elevations decline, or is inundated when elevations rise, species abundance and productivity decrease (Braden, et al. unpublished data 2002). This ephemeral habitat, thus, has a high productivity value and is beneficial to riparian-associated species when it is present.

Habitat in the delta areas may consist of (1) predominantly native willow, (2) predominantly exotic saltcedar (tamarisk sp.) or (3) mixed native willow/exotic saltcedar. The Colorado River delta has previously produced a vegetation community largely composed of native willow with relatively little saltcedar (McKernan 1997). A major factor governing the types of riparian vegetation that could establish is the timing of when sediments suitable for establishment of riparian

[12] As more fully described in Chapter 2 of the Draft BA, Lake Mead elevations are driven by downstream water use needs and Glen Canyon Dam releases, except when the Lake Mead Water Control Manual for Flood Control dictates operations. Glen Canyon releases are primarily a function of operation for delivery of water from Lake Powell in accordance with the Colorado River Compact, and Hoover Dam releases are primarily a function of non-discretionary water deliveries from Lake Mead to the lower Division States and Mexico. Thus Reclamation has very limited discretion over the management of reservoir levels in Lake Mead, and lake levels may fluctuate greatly (see discussion of Reclamation's discretion found in Chapter 2 of the Draft BA).

vegetation are exposed. Willow-dominated communities have become established in the deltas of Lake Mead only when declining reservoir elevations have coincided with the timing of willow seed dispersal. During periods when reservoir elevations have declined before or after the willow seed dispersal period, saltcedar-dominated riparian communities have become established (see Appendix M, Section M.5.3). Cottonwoods and willows that do become established when reservoir elevations decline could be lost if reservoir elevations continue to decline and groundwater elevations drop below their root depths. Conversely, riparian vegetation that becomes established on exposed sediments would be inundated and lost during wetter periods when Lake Mead reservoir elevations rise.

For example, while from 1990–1996 Lake Mead reservoir levels remained within a relatively narrow 1170–1200-foot range, creating dense stands of willow habitat (approximately 1000 acres) (McKernan and Braden 1998), the levels from 2000–2004 dropped nearly three times as much (from 1214–1125 feet), creating a delta that does not today support the same dense habitat and has created an environment in which the willows and even saltcedar are rapidly dying (USBR unpublished data 2004). This would suggest that a sustained lake level would create the best-suited habitat for the LCR MSCP covered bird species, and that extreme rises or falls in reservoir elevations would not support covered species habitat in the Lake Mead delta areas. As lake levels continue to drop, new delta habitat may form lower in the lake. This would be limited by soil conditions in submerged portions of the Lake Mead shoreline because most of the shoreline does not have the soil types necessary for the establishment of riparian vegetation. The extent of riparian vegetation that could establish as reservoir elevations decline, however, cannot be predicted.

The Previous Modeling for Lake Mead, including the Baseline and the Action Alternative, show the median elevations of the lake declining over the modeled period due to increasing Upper Basin depletions (see Figure 3). The probability of water levels historically used for vegetation establishment and survival therefore decreases over the term of the LCR MSCP. It is not clear whether similar areas of vegetation will establish and survive at lower levels. It may be that covered species habitats over time become more limited in the delta areas as the probability for lower lake levels increases. Under the 50th percentile (Figure 5), because of the lower Lake Mead initial conditions, the New Modeling indicates an increased probability of lower lake elevations until year 2024 (as compared to the Previous Modeling) and thereafter the probabilities are approximately the same. This would indicate that, during the first 25 years, the probabilities for covered species habitat establishment may be slightly more limited in those years. At the 25th percentile there is a greater reduction in reservoir elevation between the Baseline and Action Alternative under the New Modeling as compared to the Previous Modeling. In addition, this relative reduction in elevation under the New Modeling could extend to 2045 compared to 2020 under the Previous Modeling. At the 75th percentile, differences between the New and Previous Modeling are evident only during the first 10 years of the modeled period. Overall, the habitat quantity and quality would not be significantly different over the 50-year period.

Results of the New Modeling indicate that the impacts of implementing the covered activities on covered species that use riparian vegetation in the delta areas of Lake Mead would not be measurably different from those described in the Draft BA/HCP under the Previous Modeling. This is because the impact mechanisms associated with the creation and loss of riparian vegetation are the same under the New and Previous Modeling, the only difference being that riparian vegetation could be established at lower elevations under the New Modeling. The extent of exposed soils suitable for establishment of riparian vegetation could be slightly less, however, at lower elevations.

7.1.4.2 Marsh Vegetation

Ephemeral marsh vegetation can periodically establish at inflow points of Lake Mead (e.g., Lake Mead delta, Virgin River delta, Muddy River delta, Las Vegas Wash), when Lake Mead water surface elevations are below full pool elevation. This ephemeral marsh vegetation can provide nesting and dispersal habitat for marsh-associated wildlife, including the Yuma clapper rail and western least bittern covered under the LCR MSCP. Habitat that does become established when reservoir elevations decline could be lost if reservoir elevations continue to decline and groundwater elevations drop below the rooting depths of emergent vegetation. Marsh vegetation that does become established on exposed sediments would be inundated and lost during wetter periods, when Lake Mead reservoir elevations rise. The extent of habitat and attendant species benefits that could be periodically created and subsequently lost as a result of changes in reservoir elevations over the term of the modeling cannot, however, be predicted based on the available information.

As described in Section 7.1.4.1, for riparian vegetation, it is likely that a sustained lake level would create the best-suited habitat for marsh-associated LCR MSCP covered bird species, and that rises or falls in reservoir elevations would not support covered species habitat in the Lake Mead delta areas. Because the rooting depth of emergent vegetation is shallow relative to riparian trees, however, marsh vegetation could be affected by less extreme reductions in reservoir elevations than would be required to desiccate woody riparian vegetation. When lake levels drop, new marsh vegetation may form lower in the lake. This would be limited because most of the shoreline does not have the soil necessary for the establishment of marsh vegetation. The extent of marsh vegetation that could establish as reservoir elevations decline, however, cannot be predicted. Under the 50th percentile (Figure 5), because of the lower Lake Mead initial conditions, the New Modeling indicates an increased probability of lower lake elevations until year 2024 (as compared to the Previous Modeling) and thereafter the probabilities are approximately the same. This would indicate that during the first 25 years, the probabilities for the establishment of marsh vegetation that provides covered species habitat may be slightly more limited. At the 25th percentile there is a greater reduction in reservoir elevation between the Baseline and Action Alternative under the New Modeling as compared to the Previous Modeling. In addition, this relative reduction in elevation under the New Modeling could extend to 2045 compared to 2020 under the Previous Modeling. At the 75th percentile, differences between the New and Previous Modeling are evident only during the first 10 years of the modeled period. Overall, the extent and value of marsh vegetation that could provide covered species habitat under the New Modeling would not be significantly different than under the Previous Modeling.

Results of the New Modeling indicate that the impacts of implementing the covered activities on covered species that use marsh vegetation would not be measurably different from that described in the Draft BA/HCP under the Previous Modeling. This is because the impact mechanisms associated with the creation and loss of marsh vegetation are the same under the New and Previous Modeling, the only difference being that marsh vegetation could be established at lower elevations under the New Modeling. The extent of exposed soils suitable for establishment of marsh vegetation could be slightly less, however, at lower elevations.

7.1.4.3 Razorback Sucker Spawning Habitat

The analysis based on the Previous Modeling concluded the razorback sucker and associated critical habitat in Lake Mead may be affected by the proposed Action Alternative. The analysis contained in this evaluation does not modify this conclusion. However, the change in the potential degree of effect between results of the Previous Modeling and the New Modeling cannot be quantified.

As stated in the Draft BA, implementation of flow-related covered activities may result in adverse impacts on razorback sucker spawning habitat and designated critical habitat for the razorback sucker in Reach 1. The known spawning elevations that may be important for the razorback sucker occur between 1120 and 1150 feet msl in Lake Mead. Current information shows that during the spawning seasons of 1997–2001, razorback sucker spawned at or near the cliff spawning site at the back of Echo Bay. This site was dry in 2002, and spawning occurred in a different area along the south shore of Echo Bay. During the 2003 spawning season, the 2002 spawning site was dry. However, razorback sucker apparently spawned along the same shore just east of the 2002 spawning site on a gravelly point submerged in 2–5 feet of water. In 2004, larval concentrations and habitat use of a telemetered fish indicated the Echo Bay population spawned approximately 250 meters east of the 2003 site (Welker and Holden 2004). These changes in spawning location over the past few years indicate the razorback sucker will successfully move their spawning location into progressively lower elevations where suitable spawning substrate is present as the lake recedes. Findings of recent investigations (Twichell and Rudin 1999) indicate that it is unlikely that sediment accumulation over available spawning substrate will affect spawning habitat area. However, indications are that in 2004 sediment from the Las Vegas Bay delta has moved farther out and caused the presumptive spawning area in the bay to become covered with encroaching sediment and may have influenced spawning success (Welker and Holden 2004). This encroaching sediment is a result of outflow from Las Vegas Wash and is not typical of sediment encroachment in the rest of Lake Mead. That encroachment is not only a function of lowering lake levels, but is likely also related to high rainfall events and growing wastewater discharge as a result of growth in the Las Vegas area.

The number of razorback suckers present in Lake Mead represents a small percentage of the total LCR population. The 2004 population estimates for the Echo Bay population range from 23–52 fish and estimates for the Las Vegas Bay population range from 11–310 fish

(Welker and Holden 2004). To put the Lake Mead razorback sucker population in context, the largest extant population of razorback suckers in the entire Colorado River system is found in Lake Mohave (Reach 2) with an estimated population of 35,000 fish.

Results of razorback sucker studies indicate successful recruitment of minimal numbers of razorback suckers in Lake Mead during years when favorable rearing conditions are present. This makes the population of razorback suckers in Lake Mead unique in that it is the only population that has persisted over a long period of time in any portion of the LCR. However, these conditions are infrequent, and the numbers of fish naturally recruited to the population may not be sufficient to sustain the population under existing conditions. Reservoir operations and other factors that create the conditions that result in new fish successfully entering the population are not well understood. It has been postulated that during periods of lower lake elevations, vegetation becomes established along the shoreline. Then when the lake rises, the vegetation that becomes inundated provides cover for young razorback suckers. Recruitment has occurred fairly regularly from 1974–1998. Sufficient information is not available to determine if changes in reservoir elevation with implementation of the action alternative could adversely affect the current observed rate of recruitment. However, it can be postulated that due to the probability of lower lake levels in the foreseeable future, short-term annual rises in lake elevation could inundate established vegetation that would provide cover for juvenile razorback suckers, thus maintaining a similar level of recruitment to the population.

As described above, the change in effects on razorback sucker in Lake Mead from using an updated initial reservoir elevation and the additional period of record between the Previous and New Modeling results cannot be quantified. However, the results of the New Modeling do not indicate that the impacts of implementing the covered activities on the razorback sucker would be significantly different than that described in the Draft BA/HCP. With substantial recent declines in reservoir elevations, the razorback sucker has demonstrated the ability to successfully spawn on suitable substrates present at lower reservoir elevations when previously used spawning habitat is exposed and no longer available. Therefore, we conclude that spawning behavior and success would be similar under both the Previous and New Modeling.

7.1.4.4 Transitory River Segments

As described in the Draft BA/HCP, when Lake Mead reservoir elevations decline, segments of the Colorado River and Virgin River channels that existed prior to construction of Hoover Dam can become exposed within the full-pool elevation of Lake Mead (when these areas appear, they are called transitory river segments). These transitory river segments can provide for and be occupied by the humpback chub and the flannelmouth sucker, which are covered under the LCR MSCP. The few humpback chub currently occurring in the Grand Canyon could move downstream and utilize as much as an estimated 62 miles of transitory Colorado River channel that forms when reservoir elevations lower to an elevation of 950 feet msl. This is the elevation that is assumed to be protected by the modeled shortage assumptions. The flannelmouth sucker could occur in transitory river segments of both the Colorado River and Virgin River that form when reservoir elevations are below full pool elevations. This transitory habitat could be lost during wetter periods when Lake Mead reservoir elevations increase and inundate habitat.

The mechanisms described above are the same under the New Modeling and the Previous Modeling. However, the presence and extent of transitory river segments might occur more frequently under the New Modeling due to the potentially lower reservoir elevations as described in Section 7.1. Consequently, the benefits associated with creating transitory river segments that provide humpback chub and flannelmouth sucker habitat may be somewhat greater under the New Modeling assumptions than under the Previous Modeling assumptions. However, these potential beneficial effects are not considered significant because the probabilities of the entire transitory river channel becoming available at the 950 feet msl lake level are extremely low under both the Previous and New Modeling, and because such benefits would be ephemeral in nature.

7.1.4.5 Sticky Buckwheat and Threecorner Milkvetch

As described in the Draft BA/HCP, sticky buckwheat and threecorner milkvetch can establish and occur along the Lake Mead shoreline on sites that have the soil characteristics required by each species and that are exposed when Lake Mead water surface elevations are below full-pool elevation. Sticky buckwheat and threecorner milkvetch plants that establish on these sites would be inundated and lost during wetter periods, when Lake Mead reservoir elevations increase.

The mechanisms described above are the same under the New Modeling and the Previous Modeling. However, the presence and extent of exposed suitable soils that can support sticky buckwheat and threecorner milkvetch might occur more frequently under the New Modeling due to the lower reservoir elevations as described in Section 7.1. Consequently, the benefits associated with exposing suitable soils for these plant species might be somewhat greater under the New Modeling assumptions than under the Previous Modeling assumptions. However, these potential beneficial effects are not considered significant due to the ephemeral nature of any potential benefits.

7.2 EFFECT ON THE RIVER CORRIDOR (REACHES 3–5)[13]

As discussed in Section 6.3 and in Appendix J, Reclamation uses a reservoir model to project the possible future states of the reservoir system under a range of possible future inflow conditions. When analyzing impacts to the river, backwaters, and groundwater along the Colorado River corridor below Hoover Dam, more detail is necessary. Accordingly, Reclamation used a more detailed analysis to assess the potential impacts to covered species and their habitat along the river corridor below Hoover Dam.

The analysis that Reclamation utilized for Reaches 3–5 was summarized in Appendix K, Volume IV of the LCR MSCP documents ("Hydrologic Depletion Analysis of the Effects of the Changes in Points of Diversion on Backwater and Groundwater Elevations"). The analysis followed four main steps:

1) Estimate the hourly flows likely to be released from the dam, both before and after the flow reductions have been applied;
2) Route the hourly release patterns downstream to locations of interest;
3) Convert the modeled flows at each location to river stage (elevation) to determine the drawdown (reduction in river stage) due to the flow reduction; and,
4) Determine the effect of the drawdown on river width and depth, backwater area extent and depth, and depth to groundwater proximate to the river.

[13] Conditions in Reach 2 (river channel and Lake Mohave reservoir) are not expected to be measurably affected with implementation of future flow-related covered activities, as noted in Section 5.2.3.3 of the Draft BA and Section 4.2.3.3 of the Draft HCP. The new information has no effect on the hydrology in Reach 6 as described in "Reaches 6 and 7: Imperial Dam to Southerly International Boundary" in Section 5.2.2.1 of the Draft BA, and in Section 4.2.2.1 of the Draft HCP. Accordingly, no analysis of Reach 2 or 6 is made in this evaluation.

As described in Section 6, updated information with respect to the initial conditions of the reservoirs and the natural flow record is analyzed in this evaluation. This updated information only applies to analyses based on the reservoir model and does not affect the analysis of reductions in river flows and the associated analysis of effects on open water and groundwater along the river corridor, as described in Appendix K.

The updated information, however, suggests an increased probability that future shortages may occur in the Lower Basin[14]. The Draft BA/HCP analyzed reductions in flow of up to 0.845 million acre-feet per year (mafy) in the river from Hoover Dam to Davis Dam, up to 0.860 mafy in the river from Davis Dam to Parker Dam, and up to 1.574 mafy in the river from Parker Dam to Imperial Dam. The effect of the updated information does not change these analyzed amounts, but simply increases the probability that some of the analyzed amounts could be used to cover flow reduction due to shortage determinations. The hydrologic model described in Appendix J was used to quantify the effect of the updated information on the probability of future shortages.

7.2.1 Results from Previous Hydrologic Modeling

Figure 6 provides a graph of the probability of shortage under the Previous Modeling. The probability of shortage is computed by counting the number of modeled traces that incurred a shortage condition in each year and dividing by the total respective number of traces (85 traces under the Previous Modeling and 90 traces under the New Modeling, respectively). As shown in Figure 6, under the Baseline, the probability of shortage is about 48 percent in year 2016 and 2017. Thereafter, the probability varies between 38 percent and 52 percent through year 2051. By comparison, the Action Alternative shows a lower probability of shortage compared to the Baseline through year 2019. This is attributed both to the implementation of water transfers under the Action Alternative that reduce the call for surplus water from Lake Mead as explained in section 7.1.1, as well as the lower shortage elevation triggers used in the Action Alternative. The probability of shortage under the Baseline and Action Alternative is nearly the same from 2020 through 2033. The probability of shortage under the Action Alternative is somewhat higher (2 percent to 11 percent) after 2033. This higher probability can primarily be attributed to the extension of the ISG through 2051 under the Action Alternative.

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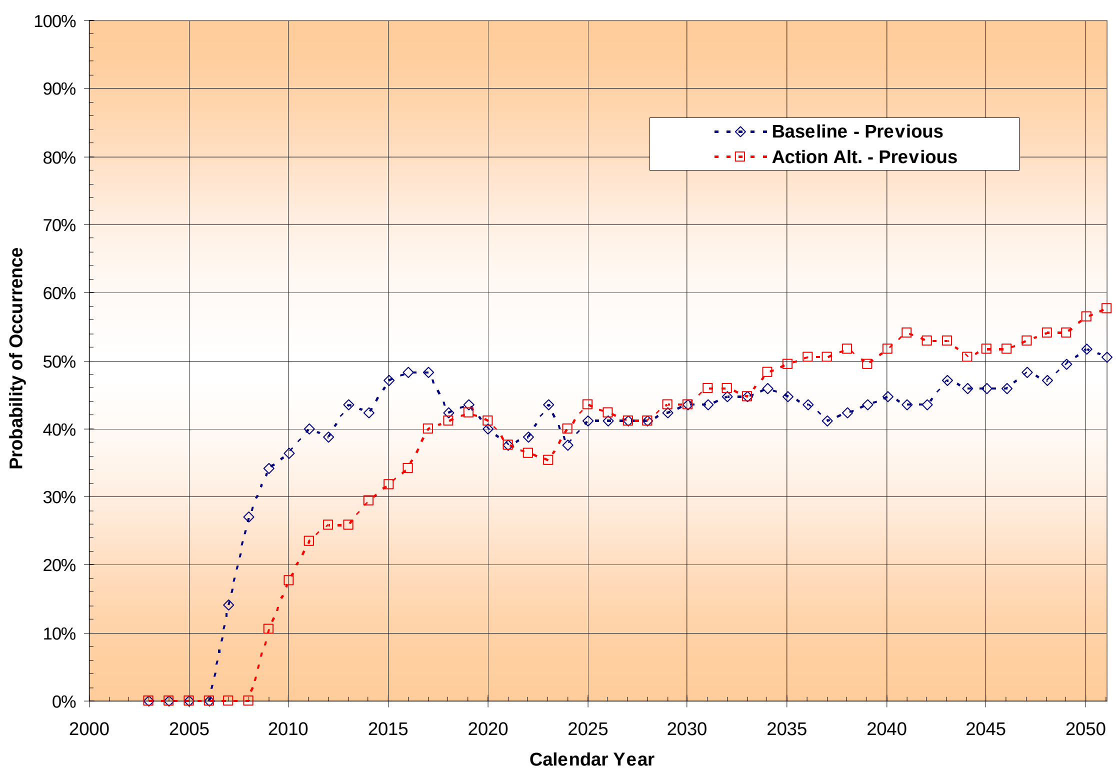
[14] Shortage determinations would result in reduced discharges from reservoir storage which would reduce flow in downstream river reaches, similar to the effect from changes in point of diversions.

7.2.2 Results from New Hydrologic Modeling

Data from the New Modeling was used to conduct a similar analysis as discussed above and is used to evaluate the effect of the updated information on the probability of future shortages. Figure 7 illustrates the probability of shortages under the New Modeling. This figure is similar to Figure 6 and compares the Baseline and Action Alternative based on the New Modeling.

Figure 7 shows trends between the Baseline and Action Alternative under the New Modeling, similar to the trends observed under the Previous Modeling. The most noticeable difference between the data shown in Figures 6 and 7 is that, under the New Modeling, there is a higher probability of shortage during the initial years. This applies to both the Baseline and Action Alternative and is attributed to the lower initial reservoir conditions that were considered in the New Modeling.

Figure 6
Previous Modeling
Probability of Shortage



As seen under the Previous Modeling and explained in Section 7.2.1, the Action Alternative shows a lower probability level compared to the Baseline in the initial years (through year 2016). Except for a few years (2028 through 2032), the probability level is, in general, somewhat higher (1 percent to 13 percent) under the Action Alternative. This higher level of probability can primarily be attributed to the extension of the ISG through 2051 under the Action Alternative.

7.2.3 Comparison of Previous and New Hydrologic Modeling

Figure 8 provides a comparison of the probability of shortage under the Previous and New Modeling. As expected, the reduced reservoir starting elevations increase the probability of shortage in the near-term (2005–2018) for both the Baseline and Action Alternative under the New Modeling. In the later years, however, the effect of the lower initial reservoir elevations is negligible and the New Modeling shows a slight decrease in the probability of shortage for both Baseline and Action Alternative. This difference is attributed to the slight increase in the natural flows as described in Section 6.2.

Figure 7
New Modeling
Probability of Shortage

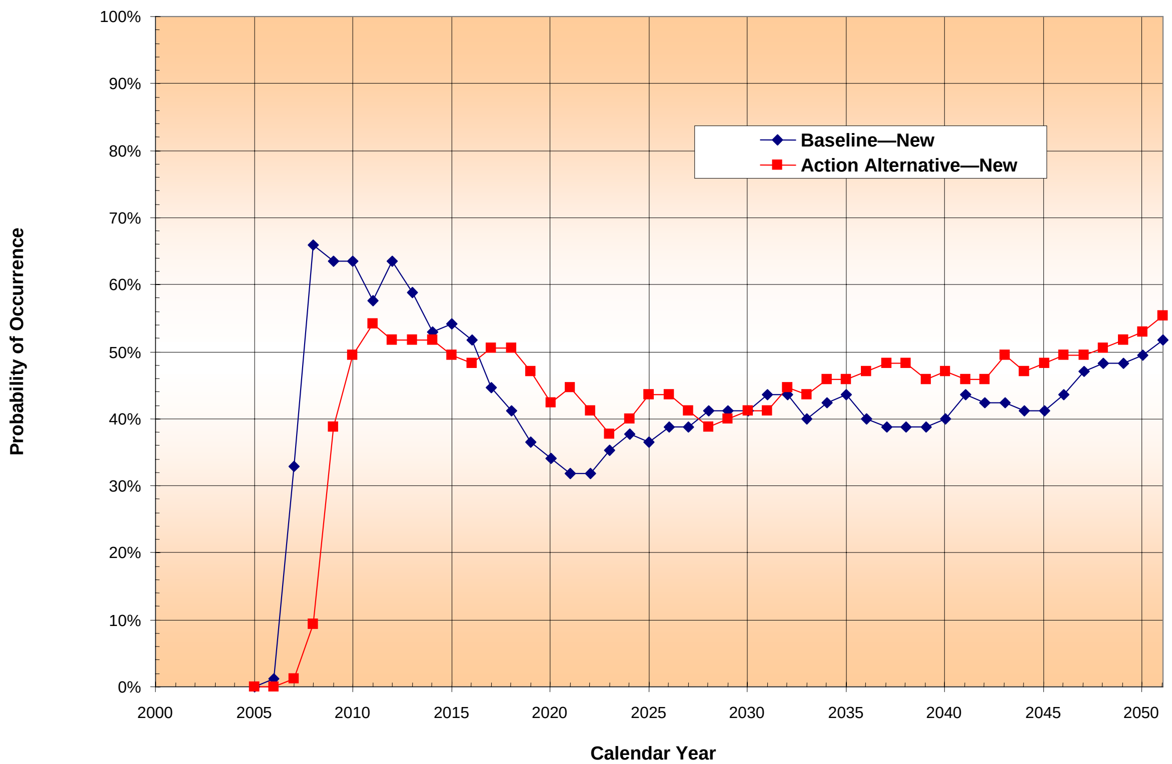
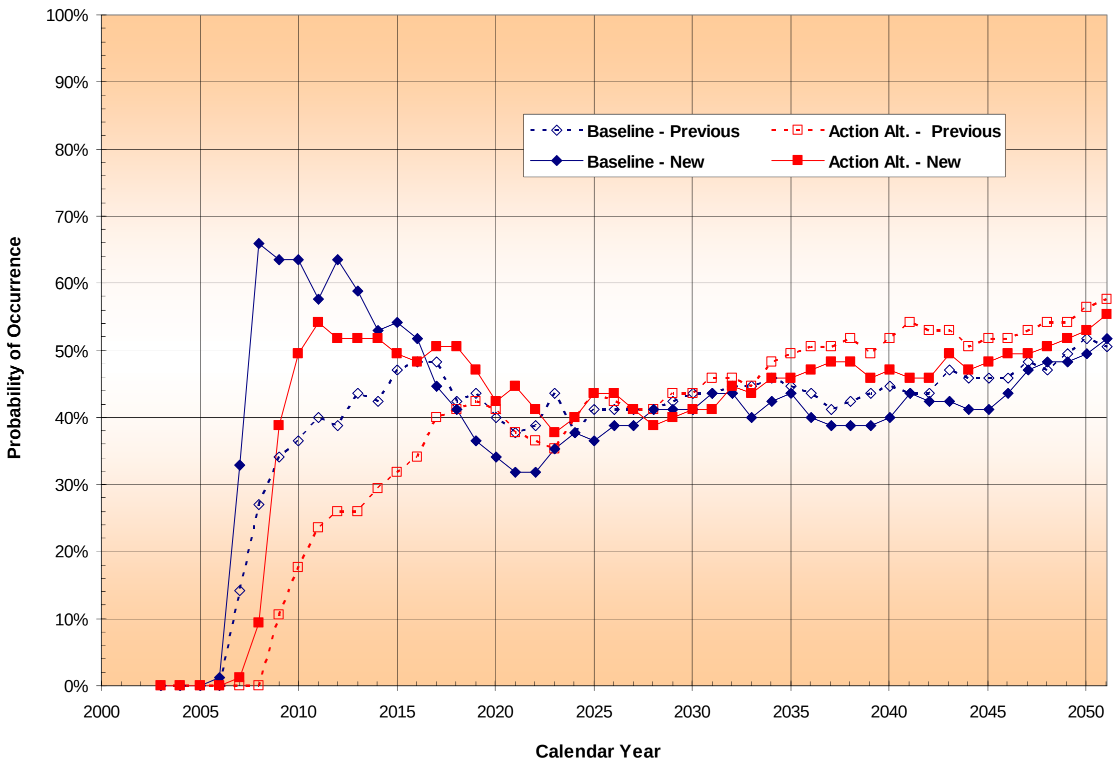


Table 4 provides a tabular comparison of the probability levels presented in Figure 8 and the relative differences due to the updated information are compared. Columns 4 and 7 of Table 4 compare the differences between the probability of shortage under the Baseline and Action Alternative under the

Previous and New Modeling, respectively. In Column 8 of this same table, the relative differences between the New and Previous Modeling results are compared. Although the New Modeling reflects an increase in the probability of shortage conditions as compared to the Previous Modeling, the relationship between the Action Alternative and the Baseline remains essentially the same–(i.e. the probability of shortage is lower under the Action Alternative in the near term and slightly increased in the later years).

Figure 8
Comparison of the New to Previous Modeling Results
Probability of Shortage



7.2.4 Analysis of Effect on Biological Resources

The covered activities described in the Draft BA/HCP allow for a reduction in flow of up to 0.845 mafy in the river from Hoover Dam to Davis Dam (Reach 2), up to 0.860 mafy in the river from Davis Dam to Parker Dam (Reach 3), and up to 1.574 mafy in the river from Parker Dam to Imperial Dam (Reaches 4 and 5). These reductions in flow could result from changes in the points of diversion, from shortage determinations, and/or from other covered activities as described in the Draft BA/HCP. Because the analysis assumes that the reduction of 1.574 maf occurs immediately, the timing of these shortages is irrelevant to the assessment of impacts (see Draft BA/HCP Section 5.2.1.3, "Key Assumptions Related to Groundwater Effects on Land Cover Types and

Covered Species Habitat”). Nothing in the updated information analyzed as part of this evaluation changes the reduction in flow coverage as identified in the Draft BA/HCP.

Accordingly, the analysis of effects of the covered activities on surface water or groundwater levels is not affected by the New Modeling. Consequently, the effects of implementing flow-related covered activities on backwater, marsh, and cottonwood-willow land cover types that provide covered species habitat are the same as described for each of the covered species in the Draft BA/HCP. Thus, there is no change in the effect to the covered species and their habitat as a result of the updated hydrologic information.

Table 4
Comparison of New to Previous Modeling
Probability of Shortage

	Previous Modeling			New Modeling			
[1]	*[2]*	*[3]*	*[4]*	*[5]*	*[6]*	*[7]*	*[8]*
Year	Baseline	Action Alternative	Difference Between Baseline and Action Alternative	Baseline	Action Alternative	Difference Between Baseline and Action Alternative	Difference Between New and Previous Modeling
2003	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2004	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2005	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2006	0.0%	0.0%	0.0%	1.2%	0.0%	-1.2%	-1.2%
2007	14.1%	0.0%	-14.1%	32.9%	1.2%	-31.8%	-17.6%
2008	27.1%	0.0%	-27.1%	65.9%	9.4%	-56.5%	-29.4%
2009	34.1%	10.6%	-23.5%	63.5%	38.8%	-24.7%	-1.2%
2010	36.5%	17.6%	-18.8%	63.5%	49.4%	-14.1%	4.7%
2011	40.0%	23.5%	-16.5%	57.6%	54.1%	-3.5%	12.9%
2012	38.8%	25.9%	-12.9%	63.5%	51.8%	-11.8%	1.2%
2013	43.5%	25.9%	-17.6%	58.8%	51.8%	-7.1%	10.6%
2014	42.4%	29.4%	-12.9%	52.9%	51.8%	-1.2%	11.8%
2015	47.1%	31.8%	-15.3%	54.1%	49.4%	-4.7%	10.6%
2016	48.2%	34.1%	-14.1%	51.8%	48.2%	-3.5%	10.6%
2017	48.2%	40.0%	-8.2%	44.7%	50.6%	5.9%	14.1%
2018	42.4%	41.2%	-1.2%	41.2%	50.6%	9.4%	10.6%
2019	43.5%	42.4%	-1.2%	36.5%	47.1%	10.6%	11.8%
2020	40.0%	41.2%	1.2%	34.1%	42.4%	8.2%	7.1%
2021	37.6%	37.6%	0.0%	31.8%	44.7%	12.9%	12.9%
2022	38.8%	36.5%	-2.4%	31.8%	41.2%	9.4%	11.8%
2023	43.5%	35.3%	-8.2%	35.3%	37.6%	2.4%	10.6%
2024	37.6%	40.0%	2.4%	37.6%	40.0%	2.4%	0.0%
2025	41.2%	43.5%	2.4%	36.5%	43.5%	7.1%	4.7%
2026	41.2%	42.4%	1.2%	38.8%	43.5%	4.7%	3.5%
2027	41.2%	41.2%	0.0%	38.8%	41.2%	2.4%	2.4%
2028	41.2%	41.2%	0.0%	41.2%	38.8%	-2.4%	-2.4%
2029	42.4%	43.5%	1.2%	41.2%	40.0%	-1.2%	-2.4%
2030	43.5%	43.5%	0.0%	41.2%	41.2%	0.0%	0.0%
2031	43.5%	45.9%	2.4%	43.5%	41.2%	-2.4%	-4.7%
2032	44.7%	45.9%	1.2%	43.5%	44.7%	1.2%	0.0%
2033	44.7%	44.7%	0.0%	40.0%	43.5%	3.5%	3.5%
2034	45.9%	48.2%	2.4%	42.4%	45.9%	3.5%	1.2%
2035	44.7%	49.4%	4.7%	43.5%	45.9%	2.4%	-2.4%
2036	43.5%	50.6%	7.1%	40.0%	47.1%	7.1%	0.0%
2037	41.2%	50.6%	9.4%	38.8%	48.2%	9.4%	0.0%
2038	42.4%	51.8%	9.4%	38.8%	48.2%	9.4%	0.0%
2039	43.5%	49.4%	5.9%	38.8%	45.9%	7.1%	1.2%
2040	44.7%	51.8%	7.1%	40.0%	47.1%	7.1%	0.0%
2041	43.5%	54.1%	10.6%	43.5%	45.9%	2.4%	-8.2%
2042	43.5%	52.9%	9.4%	42.4%	45.9%	3.5%	-5.9%
2043	47.1%	52.9%	5.9%	42.4%	49.4%	7.1%	1.2%
2044	45.9%	50.6%	4.7%	41.2%	47.1%	5.9%	1.2%
2045	45.9%	51.8%	5.9%	41.2%	48.2%	7.1%	1.2%
2046	45.9%	51.8%	5.9%	43.5%	49.4%	5.9%	0.0%
2047	48.2%	52.9%	4.7%	47.1%	49.4%	2.4%	-2.4%
2048	47.1%	54.1%	7.1%	48.2%	50.6%	2.4%	-4.7%
2049	49.4%	54.1%	4.7%	48.2%	51.8%	3.5%	-1.2%
2050	51.8%	56.5%	4.7%	49.4%	52.9%	3.5%	-1.2%
2051	50.6%	57.6%	7.1%	51.8%	55.3%	3.5%	-3.5%

7.3 EFFECT ON REACH 7[15]

This analysis discusses the potential effects of the updated information on covered species in Reach 7, which extends from the Northerly International Boundary (NIB) to the Southerly International Boundary (SIB). As discussed in Appendix L, water flowing into Reach 7 is controlled by Mexico's operation of the Morelos Diversion Dam located at the upper end of Reach 7. Currently, water generally only flows into Reach 7 under the following conditions: (1) the result of seepage from Morelos Diversion Dam; (2) flow releases from Morelos Diversion Dam (flood releases from the LCR and Gila River, and excess water Mexico does not divert); (3) return flows from canal wasteways in the United States side; and (4) groundwater accumulation from both the United States and Mexico.

As noted in Chapter 5 of the Draft BA, Chapter 4 of the Draft HCP, and Appendix L, flood control releases on the mainstem are dictated by the flood control regulations established by the U.S. Army Corps of Engineers for Lake Mead/Hoover Dam and are highly dependent on hydrologic conditions. For modeling purposes it is assumed Mexico can schedule up to 200,000 acre-feet per year (afy) over its annual allotment (pursuant to Section 3, Article 10, of the 1944 Water Treaty) during years when flood control releases occur. However, these flood control releases are typically of such magnitude that they cannot be diverted at Morelos Diversion Dam. In this document, these resulting flows in Reach 7 are termed "excess flows below Morelos Diversion Dam."

7.3.1 Results from Previous Hydrologic Modeling

The previous analysis of potential effects of the LCR MSCP on Reach 7 was summarized in Appendix L. This previous analysis was based on a comparison of future operations under Baseline and Action Alternative using the Previous Modeling. A similar analysis has been conducted for this evaluation using the New Modeling and is used to evaluate the effects of the updated hydrologic information.

As more fully discussed in Appendix L, both the frequency and magnitude of excess flows are considered important factors in restoring and maintaining riparian habitat below Morelos Diversion Dam. Mexico's management decisions at and below Morelos Diversion Dam are not modeled because of the uncertainty of what Mexico chooses to do with any water that arrives at Morelos Diversion Dam that is in excess of their allotment.[16] As such, this evaluation and the previous analyses assume that any water in excess of

[15] See footnote 11 for discussion of Reach 6.

[16] Mexico is entitled to manage and divert any quantity of water arriving at the Mexican points of diversion pursuant to Section 3, Article 10 (b) of the 1944 Water Treaty.

Mexico's scheduled normal or surplus deliveries are flows that would not be diverted by Mexico and would continue down the LCR channel below Morelos Diversion Dam through Reach 7. This assumption is necessary to be able to model the quantities of water that have the potential to flow past Morelos Diversion Dam. In actual practice, however, Mexico may divert some portion of these excess flows.

The relative differences in the probability of occurrence of flows greater than a specified volume (differences between Baseline and Action Alternative) were evaluated, as was done in the Draft BA/HCP. For this analysis, three different magnitudes or annual volumes were considered; (1) flows of any magnitude, (2) flows of greater than 250,000 acre-feet, and (3) flows of greater than 1,000,000 acre-feet. Reclamation has utilized these different flows in a number of recent environmental analyses. A volume of 250,000 acre-feet was selected because this flow volume is near the amount generally believed to be required for the scouring action needed for regeneration of riparian habitat in the river corridor in Reach 7. A volume greater than 1,000,000 acre-feet was selected because this flow volume is believed to have significantly improved habitat in Reach 7 in the past. These flows provided scouring action to promote new vegetation when the water receded, and provided essential moisture over a longer duration that benefited existing vegetation.

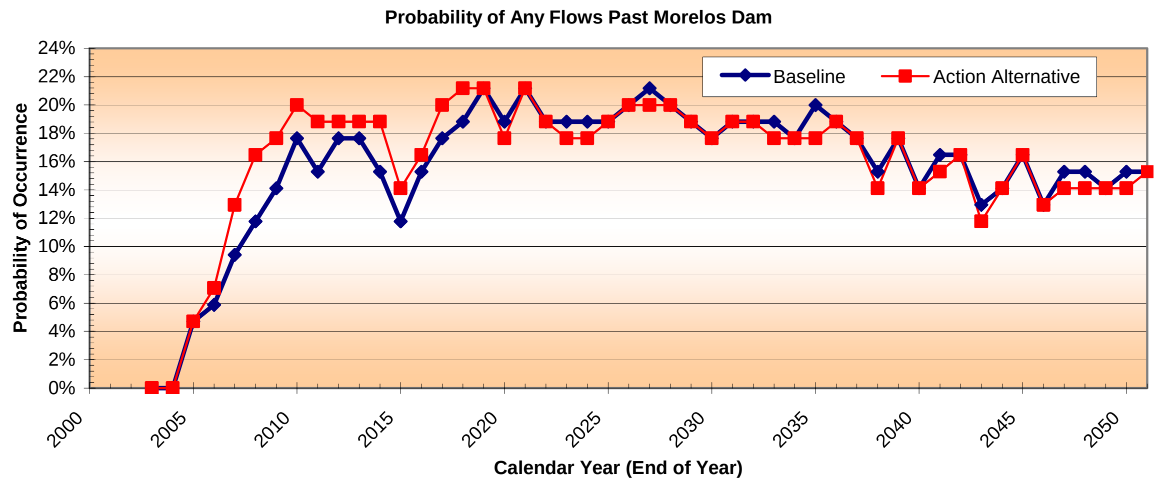
The potential for future excess flows of any magnitude under the Previous Modeling to Reach 7 is shown in the top graph of Figure 9. The probability of occurrence is computed by counting the number of modeled traces for each year that has excess annual flows and dividing by the total respective number of traces (85 traces under the Previous Modeling and 90 traces under the New Modeling). As shown in Figure 9, under Baseline, the maximum probability of occurrence of excess flows is about 21 percent and that occurs in year 2018. Thereafter, the probability follows a gradual declining trend through year 2051. This declining trend can be attributed to the increasing Upper Basin depletions. Under Baseline, the frequency of occurrence of any magnitude flow declines to about 15 percent in 2051. By comparison, the Action Alternative shows a slightly higher probability level compared to the Baseline through year 2019. This higher level of probability can be attributed to the implementation of water transfers on the LCR that reduce the call for surplus water from Lake Mead, resulting in somewhat higher Lake Mead levels. With higher Lake Mead levels, the probability of flood control releases increases. After 2019, the probability of occurrence of excess flows of any magnitude for the Baseline is equal to or is slightly less than under the Action Alternative.

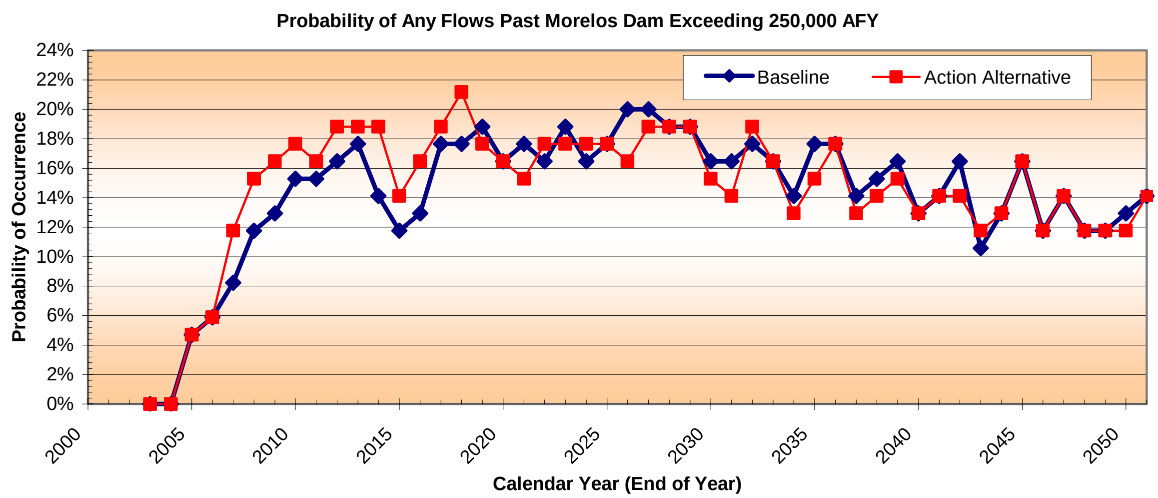
The middle graph in Figure 9 shows the probability under Previous Modeling of occurrence of excess flows of 250,000 acre-feet or greater, and the lower graph in Figure 9 shows the probability of occurrence of excess flows of 1,000,000 acre-feet or greater past Morelos Diversion Dam under the Baseline and Action Alternative.

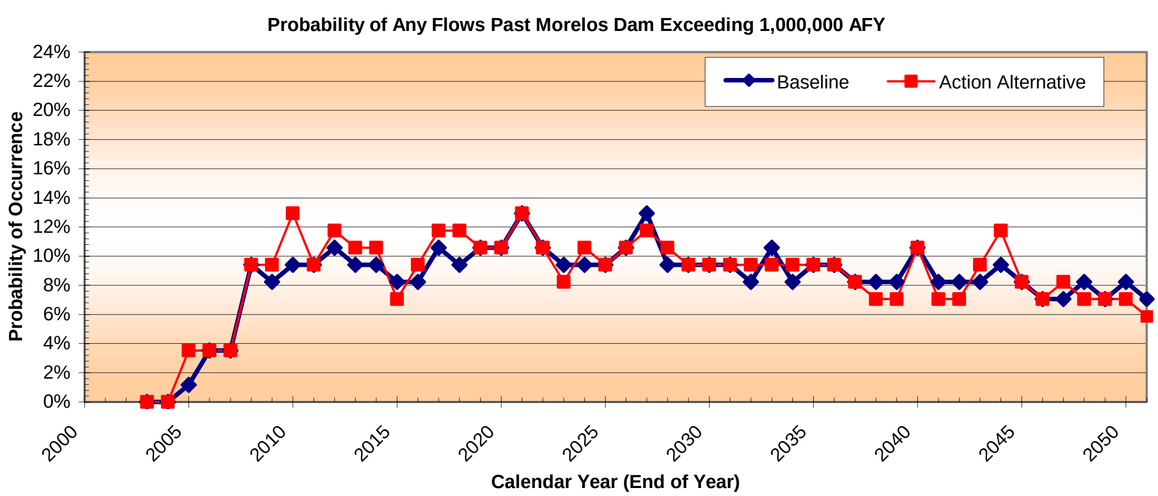
As illustrated in Figure 9, the probability of excess flows under the Baseline exceeding 250,000 acre-feet is a maximum of 20 percent in 2026 and then gradually declines to about 14 percent in 2051. Similar to the analysis of the probability of occurrence of any size flows past Morelos Diversion Dam, the Action Alternative shows a slightly higher level of probability of occurrence compared to the Baseline through about 2019. After 2019, the probability of occurrence of excess flows for the Baseline is equal to or is slightly less than under the Action Alternative. Note that probability of occurrence is generally the same for flows of any magnitude and for flows of greater than 250,000 acre-feet and the same general trend occurs for both the Baseline and Action Alternative. Again, this happens because the occurrence of excess flows is directly related to the flood control releases from Lake Mead. These conditions are largely the result of hydrologic conditions (high-flow years coupled with higher reservoir levels) and when they occur, the respective flows are generally larger than 250,000 acre-feet.

Similar patterns and trends are observed in the lower graph of Figure 9, which shows the probability of flows past Morelos Diversion Dam exceeding 1,000,000 acre-feet under the Previous Modeling. However, the probability levels are somewhat lower than those shown in the top and middle graph, showing that there are some flood control releases that are not of magnitude 1,000,000 acre-feet or greater. However, the same relative differences between the Baseline and Action Alternative occur in all three graphs in Figure 9. This is because the actions considered under the Action Alternative have a minimal effect on excess flows past Morelos Diversion Dam, again because those occurrences are largely hydrologically driven.

Figure 9
Previous Modeling
Probability of Flows Past Morelos Diversion Dam







7.3.2 Results from New Hydrologic Modeling

Data from the New Modeling was used to conduct a similar analysis as discussed above and is used to evaluate the effect of the updated hydrologic information on Reach 7. Figure 10 illustrates the probability of excess flows past Morelos Diversion Dam under the New Modeling. This figure is similar to Figure 9 and compares the Baseline and Action Alternative based on the New Modeling for 1) flows of any magnitude, 2) flows of greater than 250,000 acre-feet, and 3) flows of greater than 1,000,000 acre-feet. A comparison of the three graphs on Figure 10 to those of Figure 9 shows that similar probability levels and similar trends occur under the Previous and New Modeling. The most noticeable difference is that, under the New Modeling, there is a lower level of probability of excess flows during the initial years for all flow magnitudes. This applies to both the Baseline and Action Alternative. This can be entirely attributed to the lower initial reservoir conditions that were considered in the New Modeling. With the current lower reservoir water levels, the probability of flood control releases is reduced since there is a large amount of vacant storage capacity system-wide that will need to be filled before flood control release conditions are reached at Lake Mead. The effect of the lower initial reservoir conditions becomes negligible after year 2014.

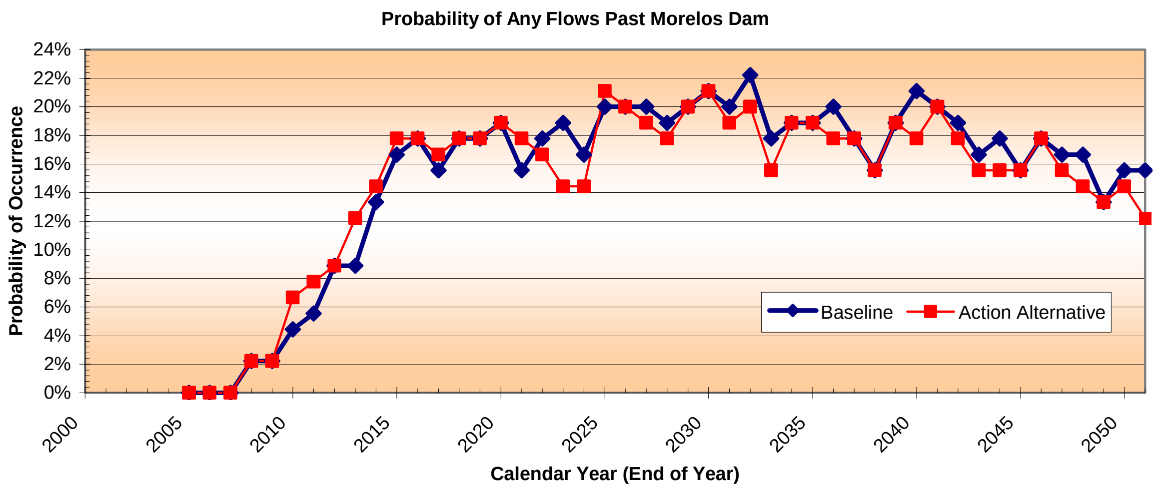
Another observation from Figure 10 is that the differences between the Baseline and Action Alternative under the New Modeling are very similar to those previously described for the Previous Modeling.

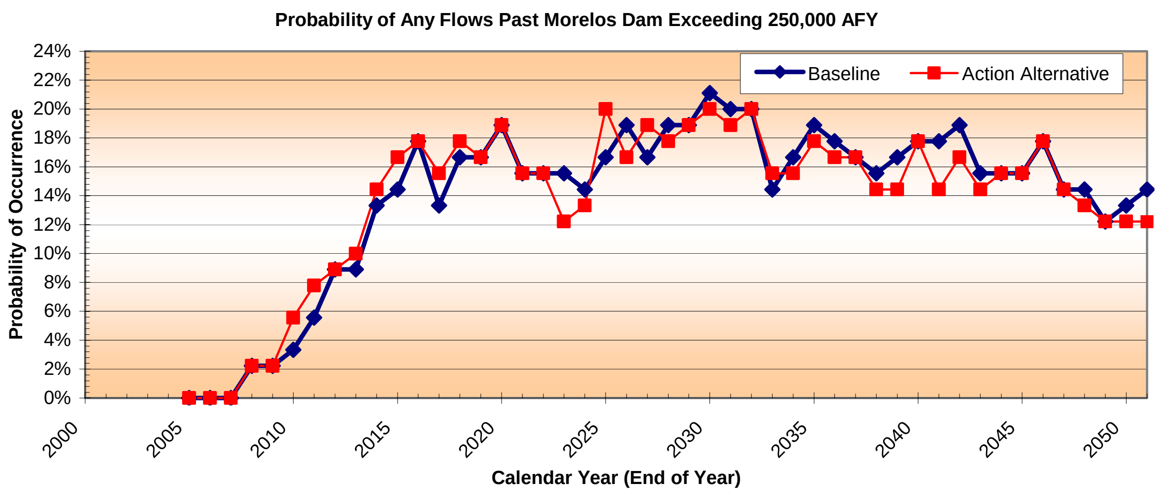
7.3.3 Comparison of the Previous and New Hydrologic Modeling

Figure 11 provides a graphical comparison of the probability levels presented in Figures 9 and 10. Tables 5, 6 and 7 provide a tabular comparison of the probability levels presented in Figures 9 and 10. Specifically, Table 5 compares the probability of occurrence of flows past Morelos Diversion Dam of any magnitude (volume) under the Previous and New Modeling. Table 6 compares the probability of occurrence of flows past Morelos Diversion Dam exceeding 250,000 acre-feet and Table 7 compares the probability of occurrence of flows past Morelos Diversion Dam exceeding 1,000,000 acre-feet under the Previous and New Modeling.

Under both the Previous and New Modeling, the Action Alternative provides the same or slightly higher probabilities than the Baseline through about 2019. After 2019, the probability of occurrence of excess flows for the Baseline is equal to or is slightly less than under the Action Alternative under both the Previous and New Modeling.

Figure 10
New Modeling
Probability of Flows Past Morelos Diversion Dam





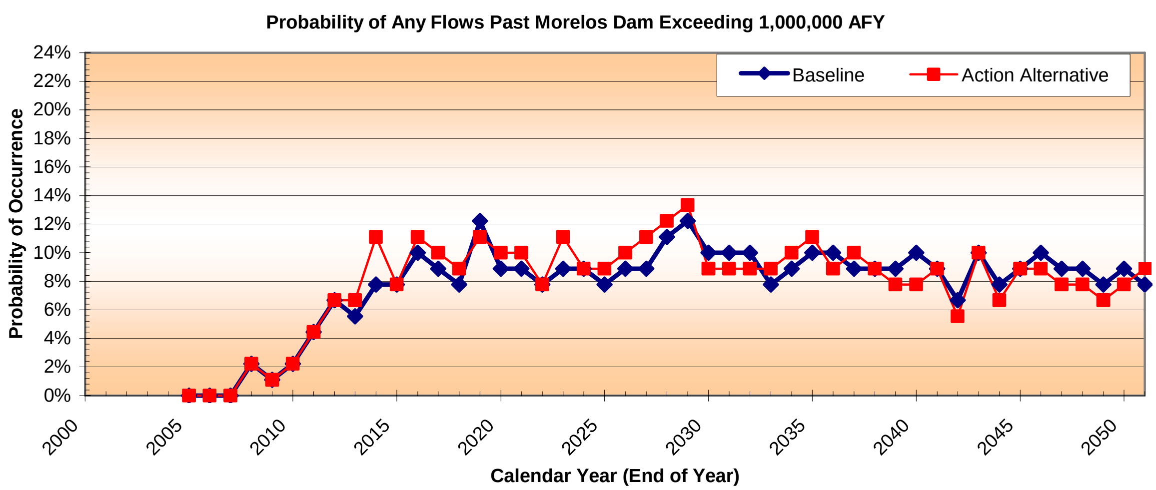
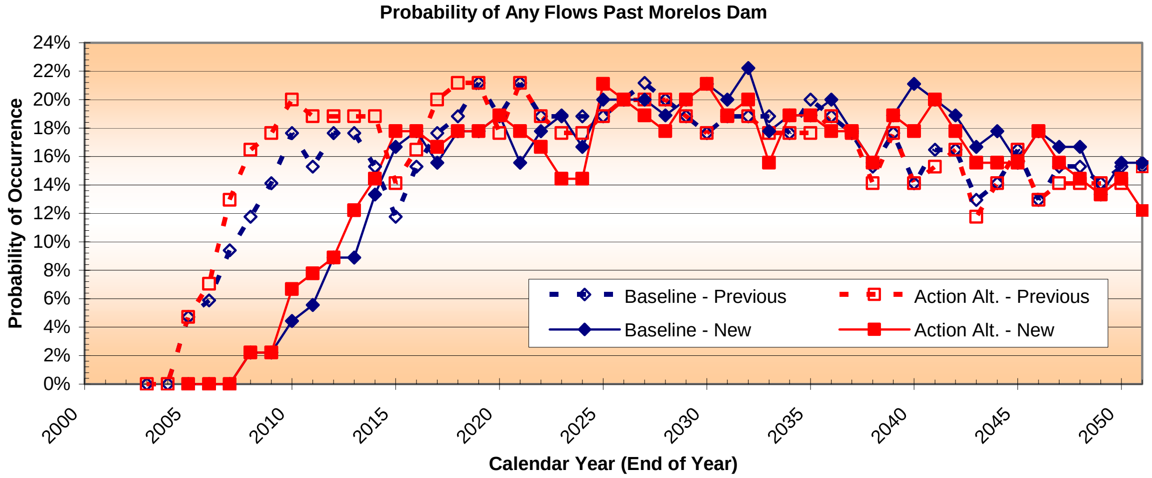
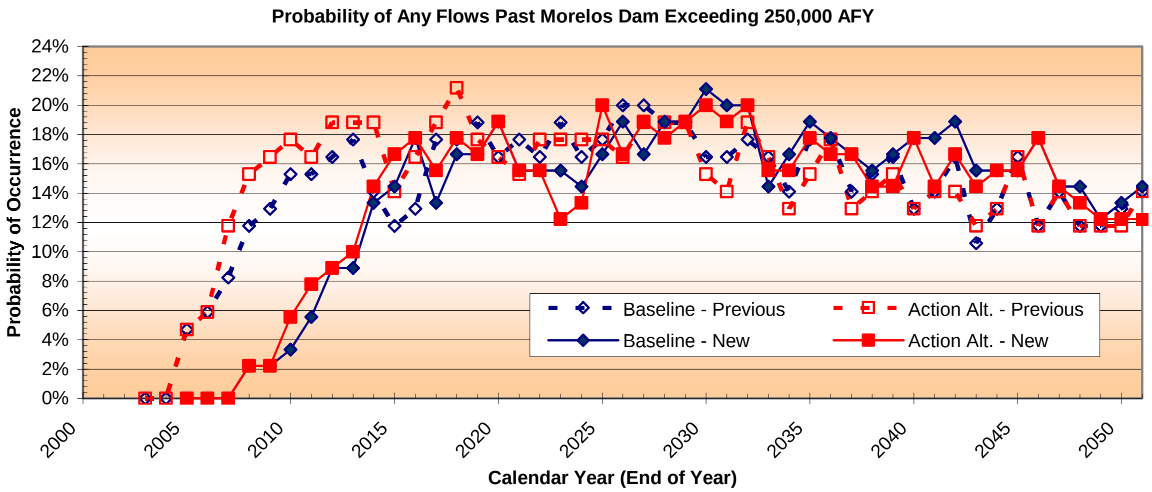


Figure 11
Comparison of New to Previous Modeling
Probability of Flows Past Morelos Diversion Dam





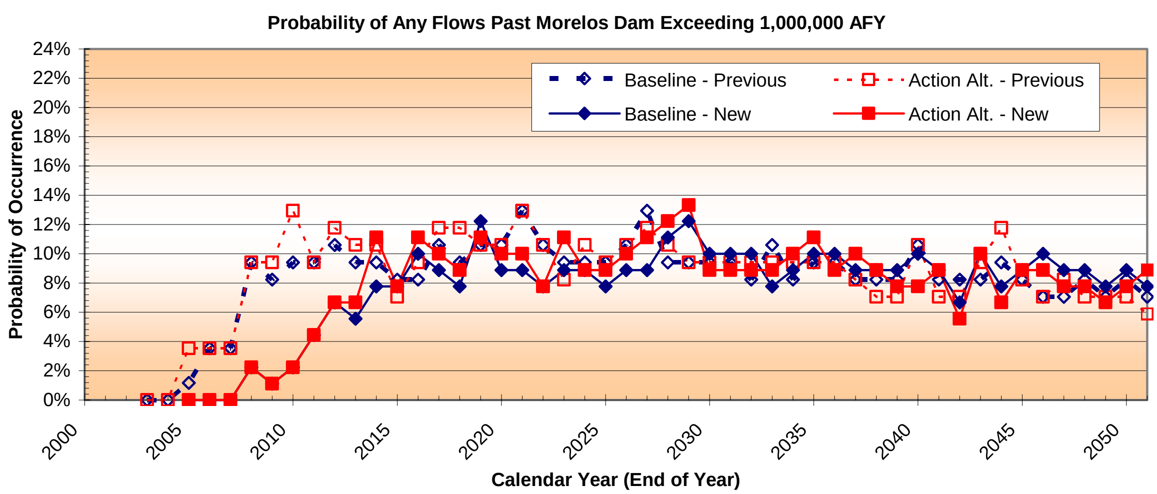


Table 5
Comparison of New to Previous Modeling
Probability of Any Flows Past Morelos Diversion Dam[17]

	Previous Modeling			New Modeling			
[1]	*[2]*	*[3]*	*[4]*	*[5]*	*[6]*	*[7]*	*[8]*
Year	Baseline	Action Alternative	Difference Between Baseline and Action Alternative	Baseline	Action Alternative	Difference Between Baseline and Action Alternative	Difference Between New and Previous Modeling
2003	0%	0%	0%				
2004	0%	0%	0%				
2005	5%	5%	0%	0%	0%	0%	0%
2006	6%	7%	1%	0%	0%	0%	-1%
2007	9%	13%	4%	0%	0%	0%	-4%
2008	12%	16%	5%	2%	2%	0%	-5%
2009	14%	18%	4%	2%	2%	0%	-4%
2010	18%	20%	2%	4%	7%	2%	0%
2011	15%	19%	4%	6%	8%	2%	-1%
2012	18%	19%	1%	9%	9%	0%	-1%
2013	18%	19%	1%	9%	12%	3%	2%
2014	15%	19%	4%	13%	14%	1%	-2%
2015	12%	14%	2%	17%	18%	1%	-1%
2016	15%	16%	1%	18%	18%	0%	-1%
2017	18%	20%	2%	16%	17%	1%	-1%
2018	19%	21%	2%	18%	18%	0%	-2%
2019	21%	21%	0%	18%	18%	0%	0%
2020	19%	18%	-1%	19%	19%	0%	1%
2021	21%	21%	0%	16%	18%	2%	2%
2022	19%	19%	0%	18%	17%	-1%	-1%
2023	19%	18%	-1%	19%	14%	-4%	-3%
2024	19%	18%	-1%	17%	14%	-2%	-1%
2025	19%	19%	0%	20%	21%	1%	1%
2026	20%	20%	0%	20%	20%	0%	0%
2027	21%	20%	-1%	20%	19%	-1%	0%
2028	20%	20%	0%	19%	18%	-1%	-1%
2029	19%	19%	0%	20%	20%	0%	0%
2030	18%	18%	0%	21%	21%	0%	0%
2031	19%	19%	0%	20%	19%	-1%	-1%
2032	19%	19%	0%	22%	20%	-2%	-2%
2033	19%	18%	-1%	18%	16%	-2%	-1%
2034	18%	18%	0%	19%	19%	0%	0%
2035	20%	18%	-2%	19%	19%	0%	2%
2036	19%	19%	0%	20%	18%	-2%	-2%
2037	18%	18%	0%	18%	18%	0%	0%
2038	15%	14%	-1%	16%	16%	0%	1%
2039	18%	18%	0%	19%	19%	0%	0%
2040	14%	14%	0%	21%	18%	-3%	-3%
2041	16%	15%	-1%	20%	20%	0%	1%
2042	16%	16%	0%	19%	18%	-1%	-1%
2043	13%	12%	-1%	17%	16%	-1%	0%
2044	14%	14%	0%	18%	16%	-2%	-2%
2045	16%	16%	0%	16%	16%	0%	0%
2046	13%	13%	0%	18%	18%	0%	0%
2047	15%	14%	-1%	17%	16%	-1%	0%
2048	15%	14%	-1%	17%	14%	-2%	-1%
2049	14%	14%	0%	13%	13%	0%	0%
2050	15%	14%	-1%	16%	14%	-1%	0%
2051	15%	15%	0%	16%	12%	-3%	-3%

[17] Although the modeling results are at a high precision, differences presented in this table reflect rounding to the nearest integer value.

Table 6
Comparison of New to Previous Modeling
Probability of Flows Past Morelos Diversion Dam Exceeding 250,000 Acre-Feet[18]

	Previous Modeling			New Modeling			
[1]	*[2]*	*[3]*	*[4]*	*[5]*	*[6]*	*[7]*	*[8]*
Year	Baseline	Action Alternative	Difference Between Baseline and Action Alternative	Baseline	Action Alternative	Difference Between Baseline and Action Alternative	Difference Between New and Previous Modeling
2003	0%	0%	0%				
2004	0%	0%	0%				
2005	5%	5%	0%	0%	0%	0%	0%
2006	6%	6%	0%	0%	0%	0%	0%
2007	8%	12%	4%	0%	0%	0%	-4%
2008	12%	15%	4%	2%	2%	0%	-4%
2009	13%	16%	4%	2%	2%	0%	-4%
2010	15%	18%	2%	3%	6%	2%	0%
2011	15%	16%	1%	6%	8%	2%	1%
2012	16%	19%	2%	9%	9%	0%	-2%
2013	18%	19%	1%	9%	10%	1%	0%
2014	14%	19%	5%	13%	14%	1%	-4%
2015	12%	14%	2%	14%	17%	2%	0%
2016	13%	16%	4%	18%	18%	0%	-4%
2017	18%	19%	1%	13%	16%	2%	1%
2018	18%	21%	4%	17%	18%	1%	-2%
2019	19%	18%	-1%	17%	17%	0%	1%
2020	16%	16%	0%	19%	19%	0%	0%
2021	18%	15%	-2%	16%	16%	0%	2%
2022	16%	18%	1%	16%	16%	0%	-1%
2023	19%	18%	-1%	16%	12%	-3%	-2%
2024	16%	18%	1%	14%	13%	-1%	-2%
2025	18%	18%	0%	17%	20%	3%	3%
2026	20%	16%	-4%	19%	17%	-2%	1%
2027	20%	19%	-1%	17%	19%	2%	3%
2028	19%	19%	0%	19%	18%	-1%	-1%
2029	19%	19%	0%	19%	19%	0%	0%
2030	16%	15%	-1%	21%	20%	-1%	0%
2031	16%	14%	-2%	20%	19%	-1%	1%
2032	18%	19%	1%	20%	20%	0%	-1%
2033	16%	16%	0%	14%	16%	1%	1%
2034	14%	13%	-1%	17%	16%	-1%	0%
2035	18%	15%	-2%	19%	18%	-1%	1%
2036	18%	18%	0%	18%	17%	-1%	-1%
2037	14%	13%	-1%	17%	17%	0%	1%
2038	15%	14%	-1%	16%	14%	-1%	0%
2039	16%	15%	-1%	17%	14%	-2%	-1%
2040	13%	13%	0%	18%	18%	0%	0%
2041	14%	14%	0%	18%	14%	-3%	-3%
2042	16%	14%	-2%	19%	17%	-2%	0%
2043	11%	12%	1%	16%	14%	-1%	-2%
2044	13%	13%	0%	16%	16%	0%	0%
2045	16%	16%	0%	16%	16%	0%	0%
2046	12%	12%	0%	18%	18%	0%	0%
2047	14%	14%	0%	14%	14%	0%	0%
2048	12%	12%	0%	14%	13%	-1%	-1%
2049	12%	12%	0%	12%	12%	0%	0%
2050	13%	12%	-1%	13%	12%	-1%	0%
2051	14%	14%	0%	14%	12%	-2%	-2%

[18] Although the modeling results are at a high precision, differences presented in this table reflect rounding to the nearest integer value

Table 7
Comparison of New to Previous Modeling
Probability of Flows Past Morelos Diversion Dam Exceeding 1,000,000 Acre-Feet[19]

	Previous Modeling			**New Modeling**			
[1]	*[2]*	*[3]*	*[4]*	*[5]*	*[6]*	*[7]*	*[8]*
Year	**Baseline**	**Action Alternative**	**Difference Between Baseline and Action Alternative**	**Baseline**	**Action Alternative**	**Difference Between Baseline and Action Alternative**	**Difference Between New and Previous Modeling**
2003	0%	0%	0%				
2004	0%	0%	0%				
2005	1%	4%	2%	0%	0%	0%	-2%
2006	4%	4%	0%	0%	0%	0%	0%
2007	4%	4%	0%	0%	0%	0%	0%
2008	9%	9%	0%	2%	2%	0%	0%
2009	8%	9%	1%	1%	1%	0%	-1%
2010	9%	13%	4%	2%	2%	0%	-4%
2011	9%	9%	0%	4%	4%	0%	0%
2012	11%	12%	1%	7%	7%	0%	-1%
2013	9%	11%	1%	6%	7%	1%	0%
2014	9%	11%	1%	8%	11%	3%	2%
2015	8%	7%	-1%	8%	8%	0%	1%
2016	8%	9%	1%	10%	11%	1%	0%
2017	11%	12%	1%	9%	10%	1%	0%
2018	9%	12%	2%	8%	9%	1%	-1%
2019	11%	11%	0%	12%	11%	-1%	-1%
2020	11%	11%	0%	9%	10%	1%	1%
2021	13%	13%	0%	9%	10%	1%	1%
2022	11%	11%	0%	8%	8%	0%	0%
2023	9%	8%	-1%	9%	11%	2%	3%
2024	9%	11%	1%	9%	9%	0%	-1%
2025	9%	9%	0%	8%	9%	1%	1%
2026	11%	11%	0%	9%	10%	1%	1%
2027	13%	12%	-1%	9%	11%	2%	3%
2028	9%	11%	1%	11%	12%	1%	0%
2029	9%	9%	0%	12%	13%	1%	1%
2030	9%	9%	0%	10%	9%	-1%	-1%
2031	9%	9%	0%	10%	9%	-1%	-1%
2032	8%	9%	1%	10%	9%	-1%	-2%
2033	11%	9%	-1%	8%	9%	1%	2%
2034	8%	9%	1%	9%	10%	1%	0%
2035	9%	9%	0%	10%	11%	1%	1%
2036	9%	9%	0%	10%	9%	-1%	-1%
2037	8%	8%	0%	9%	10%	1%	1%
2038	8%	7%	-1%	9%	9%	0%	1%
2039	8%	7%	-1%	9%	8%	-1%	0%
2040	11%	11%	0%	10%	8%	-2%	-2%
2041	8%	7%	-1%	9%	9%	0%	1%
2042	8%	7%	-1%	7%	6%	-1%	0%
2043	8%	9%	1%	10%	10%	0%	-1%
2044	9%	12%	2%	8%	7%	-1%	-3%
2045	8%	8%	0%	9%	9%	0%	0%
2046	7%	7%	0%	10%	9%	-1%	-1%
2047	7%	8%	1%	9%	8%	-1%	-2%
2048	8%	7%	-1%	9%	8%	-1%	0%
2049	7%	7%	0%	8%	7%	-1%	-1%
2050	8%	7%	-1%	9%	8%	-1%	0%
2051	7%	6%	-1%	8%	9%	1%	2%

[19] Although the modeling results are at a high precision, differences presented in this table reflect rounding to the nearest integer value

As noted before, the most noticeable difference is that under the New Modeling there is a lower level of probability of excess flows during the initial years for all flow magnitudes. This is attributed to the lower initial reservoir conditions that were considered in the New Modeling. The effect of the lower initial reservoir conditions becomes negligible after year 2014. This applies to both the Baseline and Action Alternative.

7.3.4 Analysis of Effect on Biological Resources

Excess flows below Morelos Diversion Dam are a potential mechanism for creating soil moisture conditions necessary for the natural establishment of cottonwood and willow trees that provide habitat for cottonwood-willow associated covered species. Based on the Previous Modeling, the Draft BA/HCP indicated that implementation of the flow-related covered activities was not expected to measurably affect river channel conditions in Reach 7. As described in Section 7.3.2, results of the New Modeling indicate somewhat lower probabilities for flows passing Morelos Diversion Dam during the initial years (Tables 5, 6, and 7). This is attributed to the lower initial reservoir conditions that were considered in the New Modeling. However, under both the Previous and New Modeling, the Action Alternative provides the same slightly higher probabilities than Baseline through about year 2019. Thereafter, the probability of flows passing Morelos Diversion Dam under the Action Alternative is equal to or is slightly less than under the Baseline, under both the Previous and New Modeling.

The change in probabilities for excess flows below Morelos Diversion Dam with implementation of the Action Alternative between the Previous Modeling and the New Modeling are minimal and would not change the effects on covered species habitats as described in the Draft BA/HCP.

8. CONCLUSIONS

This evaluation concludes that the inclusion of this updated hydrologic information does not identify any significant new impacts or change the conclusions of effect to covered species in the Draft BA/HCP, and no changes are required to the BA, HCP, or EIS/EIR.

8.1 LAKE MEAD WATER SURFACE ELEVATIONS

8.1.1 Riparian Vegetation

Because of the lower Lake Mead initial conditions, the New Modeling (for the 50th percentile) indicates an increased probability of lower lake elevations until year 2024 (as compared to the Previous Modeling) and thereafter the probabilities are approximately the same. This would indicate that during the first 25 years, the probabilities for covered species habitat establishment may be slightly more limited in those years. Overall, however, the habitat quantity and quality would not be significantly different over the 50-year period.

Results of the New Modeling indicate that the impacts of implementing the covered activities on covered species that use riparian vegetation in delta areas of Lake Mead would not be measurably different from that described in the Draft BA/HCP under the Previous Modeling. This is because the impact mechanisms associated with the creation and loss of riparian vegetation are the same under the New and Previous Modeling, the only difference being that riparian vegetation could be established at lower elevations under the New Modeling. The extent of exposed soils suitable for establishment of riparian vegetation could be slightly less, however, at lower elevations.

8.1.2 Marsh Vegetation

Because of the lower Lake Mead initial conditions, the New Modeling (for the 50th percentile) indicates an increased probability of lower lake elevations until year 2024 (as compared to the Previous Modeling), and thereafter the probabilities are approximately the same. This would indicate that during the first 25 years, the probabilities for the establishment of marsh vegetation that provides covered species habitat may be slightly more limited. Overall, however, the extent and value of marsh vegetation that could provide covered species habitat under the New Modeling would not be significantly different than under the Previous Modeling.

Results of the New Modeling indicate that the impacts of implementing the covered activities on covered species that use marsh vegetation would not be measurably different from those described in the Draft BA/HCP under the Previous Modeling. This is because the impact mechanisms associated with the creation and loss of marsh vegetation are the same under the New and Previous Modeling, the only difference being that marsh vegetation could be established at lower elevations under the New Modeling. The extent of exposed soils suitable for establishment of marsh vegetation could be slightly less, however, at lower elevations.

8.1.3 Razorback Sucker

The results of the New Modeling do not indicate that the impacts of implementing the covered activities on the razorback sucker would be measurably different than those described in the Draft BA/HCP. With substantial recent declines in reservoir elevations, the razorback sucker has demonstrated the ability to successfully spawn on suitable substrates present at lower reservoir elevations when previously used spawning habitat is exposed and no longer available. Therefore, we conclude that spawning behavior and success would be similar under both the Previous and New Modeling.

8.1.4 Transitory River Segments

The presence and extent of transitory river segments might occur more frequently under the New Modeling due to the potentially lower reservoir elevations as described in Section 7.1. Consequently, the benefits associated with creating transitory river segments that provide humpback chub and flannelmouth sucker habitat may be somewhat greater under the New Modeling assumptions than under the Previous Modeling assumptions. However, these potential beneficial effects are not considered significant because the probabilities of the entire transitory river channel becoming available at the 950 feet msl lake level are extremely low under both the Previous and New Modeling, and because such benefits would be ephemeral in nature.

8.1.5 Sticky Buckwheat and Threecorner Milkvetch

The presence and extent of exposed suitable soils that can support sticky buckwheat and threecorner milkvetch might occur more frequently under the New Modeling due to the lower reservoir elevations as described in Section 7.1. Consequently, the benefits associated with exposing suitable soils for these plant species might be somewhat greater under the New Modeling assumptions than under the Previous Modeling assumptions. However, these potential beneficial effects are not considered significant due to the ephemeral nature of any potential benefits.

8.2 EFFECT ON THE RIVER CORRIDOR

The analysis of effects of the covered activities on surface water or groundwater levels is not affected by the New Modeling. Consequently, the effects of implementing flow-related covered activities on backwater, marsh, and cottonwood-willow land cover types that provide covered species habitat are the same as described for each of the covered species in the Draft BA/HCP. Accordingly, there is no change in the effect to the covered species and their habitat as a result of the updated hydrologic information.

8.3 EFFECT ON FLOWS IN REACH 7

Results of the New Modeling indicate somewhat lower probabilities for flows passing Morelos Diversion Dam during the initial years (Tables 5, 6, and 7). This is attributed to the lower initial reservoir conditions that were considered in the New Modeling. However, under both the Previous and New Modeling, the Action Alternative provides the same slightly higher probabilities than Baseline through about year 2019. Thereafter, the probability of flows passing Morelos Diversion

Dam under the Action Alternative is equal to or is slightly less than under the Baseline, under both the Previous and New Modeling.

The change in probabilities for excess flows below Morelos Diversion Dam with implementation of the Action Alternative between the Previous Modeling and the New Modeling are minimal and would not change the effects on covered species habitats as described in the Draft BA/HCP.

9. REFERENCES

McKernan, R. L. 1997. *Status, distribution, and habitat affinities of the southwestern willow flycatcher along the lower Colorado River: Year 1 – 1996.* Prepared for U.S. Bureau of Reclamation, Lower Colorado River Region, Boulder City, NV, and U.S. Fish and Wildlife Service, Carlsbad Field Office, Carlsbad, CA.

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10. PERSONAL COMMUNICATIONS

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11. ACRONYMS

afy	acre-feet per year
BA	Biological Assessment
CEQ	Council on Environmental Quality

CEQA	California Environmental Quality Act
C.F.R.	Code of Federal Regulations
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ESA	Federal Endangered Species Act
FR	Federal Register
HCP	Habitat Conservation Plan
ISG	Interim Surplus Guidelines
ISM	Index Sequential Method
kaf	thousand acre-feet
LCR	Lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Habitat Conservation Plan
msl	mean sea level
maf	million acre-feet
mafy	million acre-feet per year
NEPA	National Environmental Policy Act
NIB	Northerly International Boundary
SIB	Southerly International Boundary
USBR	U.S. Bureau of Reclamation

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